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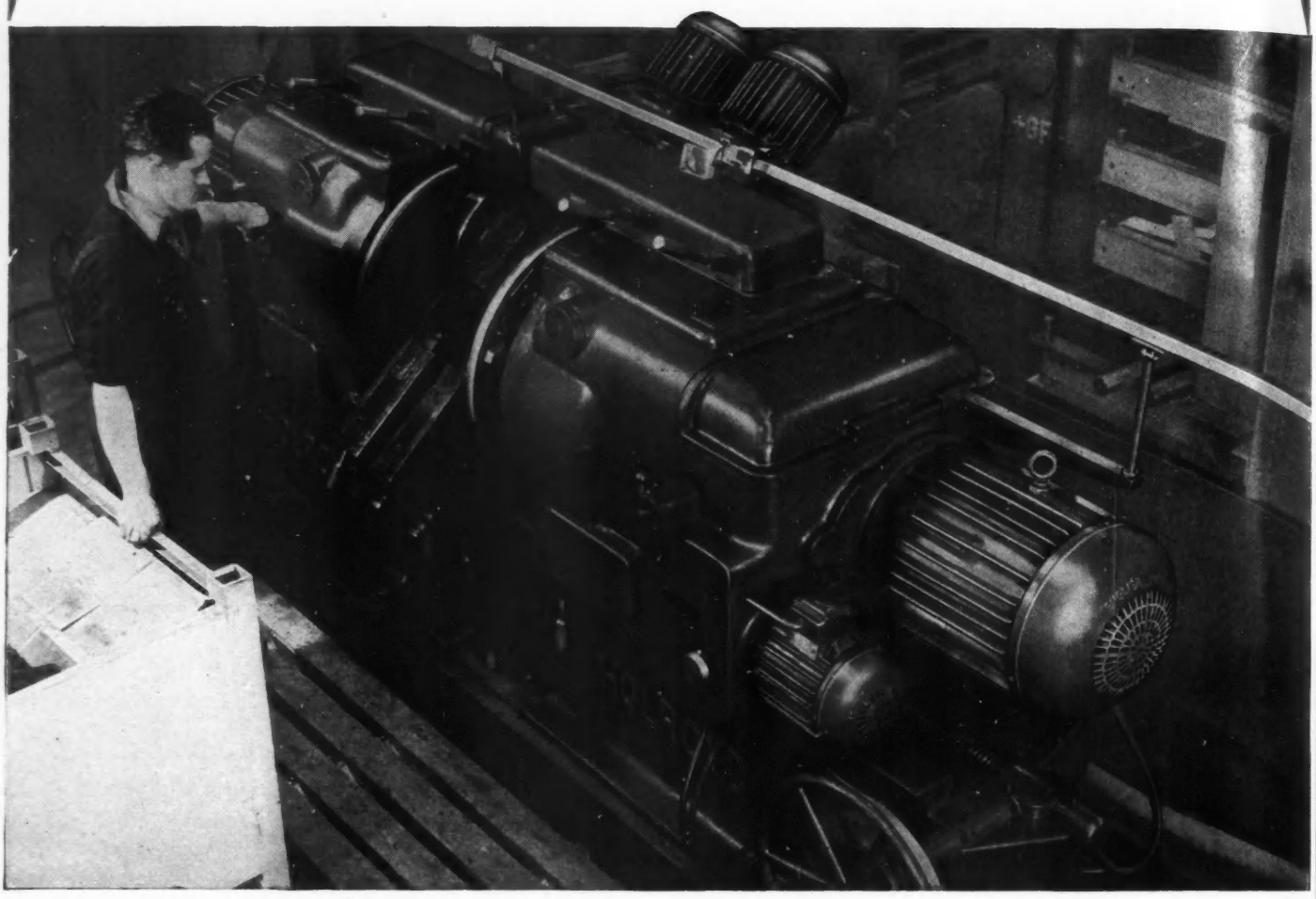

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WORKS TRAINING FOR GRADUATES

Ever since the end of the war the limelight has tended to be turned upon the academic side of the education of engineers. There, as a consequence of much discussion, including informed comment about methods employed in other countries, something approaching finality has been reached in the nation's plans for expanding universities and colleges and for making a new award available. But there are two sides to an engineer's work and in this country the need for practical training has always been heavily stressed. There the situation is still fluid. Nobody doubts, as a general statement of the situation, that all budding engineers should have some practical training. But how much? And do all budding engineers need the same length of practical training, regardless of the kind of activity on which they are likely to specialise later in life? More and more, it is suggested, the professional engineer is becoming valued for his academic attainments; less and less are engineering problems being solved intuitively, as they were in the past, through the acquirement by practical experience of a "feeling" for design and knowledge of established production, erection, and maintenance methods. Ought not academic training to be lengthened—the normal undergraduate period of three years in Britain compares with four and five years abroad—and practical training to be curtailed? These questions relate in particular to those who aim to become professional engineers through the taking of full-time courses leading to degrees or equivalent qualifications. For those following sandwich courses or pursuing their objective through part-time day release they become slightly different. The desirability of lengthy practical training is for them not questioned; but the content of that practical training is.

These questions are of particular interest to the major engineering institutions which have within this country become effectively the qualifying bodies for professional engineers. It is they who, in the past, have insisted that no one shall be elected to corporate membership who has not experienced a practical training of some minimum specified length; and it is they who may now feel that owing to that insistence on the importance of practical training they may be turning away, as unqualified, young men likely to pursue distinguished careers in engineering. The evidence that they are giving attention to the matter is provided by a booklet lying before us as we write. It has just been issued by the Institution of Electrical Engineers and is entitled "The Training of Graduates." As, over the years, it has been noticeable that the major engineering institutions tend to give attention at similar times to similar subjects, we do not doubt that other institutions are studying the same subject. Two things attract notice in the "Electricals" document. It has, of course, been produced by a committee representative particularly of industry and in part of those firms in industry that provide practical training for graduates. It therefore reflects the views of engineers in industry about the qualities they expect to find in fully trained engineers. Their view clearly is that the kind of training required cannot be experienced in a period of less than two years. But it is also their view that after a relatively short period of basic workshop training, sufficient only to familiarise a trainee with the uses and limitations of tools and materials, not to make him proficient in handling them, the rest of the training should progressively become more specialised according to the accomplishments of the trainee. Industry, in fact, has moved far from the idea prevalent thirty or forty years ago, that all that was necessary was to move a youngster to different departments of a works and let him pick up such knowledge as he could. Consciously, nowadays, industry is setting out to train graduates specifically for the kind of job, in production, in design, in research, or in operation and maintenance, that they will undertake in later life. The other factor that comes out of the report is the need to spread the training effort over a greater number of firms. Taking into account trainees from overseas, for whom it is well worth while, in the longer view, to make provision,

firms at present engaged in training feel that they cannot undertake to train all the graduates who will emerge from universities and colleges when facilities for academic education have been expanded. There are clear suggestions in the document that they have it in mind that firms without the resources to give the full training envisaged could assist industry and themselves by co-operating with one another in operating joint training schemes.

GEORGE JACKSON CHURCHWARD

Last week, British Railways, and the Western Region in particular, commemorated the centenary year of the birth of a great engineer, one of the greatest railway engineers of all time. G. J. Churchward, born at Stoke Gabriel in September, 1857, came of yeoman stock. But Brunel had lately carried the South Devon Railway near to his birthplace on its way to the West, and whereas Churchward's ancestors had for centuries past farmed rich lands on the banks of the Dart, young George was apprenticed as a railway mechanical engineer at Newton Abbot. How, subsequently, he went to Swindon, how he rose rapidly through many posts until he became principal assistant to William Dean, is a story in itself. Even before he succeeded to the post of Locomotive, Carriage and Wagon Superintendent of the Great Western Railway in 1902, he had put forward a scheme for standardising locomotive design, and reducing the number of classes to a minimum ; this standardisation proved to be one of his greatest achievements, not merely for itself, but for the manner in which the scheme proved capable of extension and continuance for more than twenty-five years after his retirement. As a locomotive designer his great contributions were the tapered boiler (the amazing capacity of which is still being exploited by his successors at Swindon in their latest development of the " King " class locomotives), and the long-lap, long-travel piston valve. In carriage design, with the famous 70ft stock, he succeeded in making a major reduction in coach weight per passenger, since his " thirds," having a tare weight of 33 tons, provided very comfortable seating for eighty persons.

But Churchward is remembered as much for his personality as for his engineering achievement. Many men who have been great designers, or great inventors were individualists to a degree. On the other hand, one of Churchward's greatest qualities was his leadership, and his ability to develop qualities of leadership in others. Many of the more successful details on Great Western locomotives were the work of members of his staff, to whom problems had been put by the chief. He liked nothing better than to spend an hour or so in the drawing-office discussing a problem, not only with the seniors but with the younger men on the job. And as men were marked out for promotion to the higher posts they served in both locomotive and carriage sections of the Swindon works, at the divisional outstations, and in the drawing-office, so that their ultimate experience should be as wide as possible. Churchward's work at Swindon proved a fount of inspiration for locomotive engineers in many parts of the world. It greatly influenced the work of R. E. L. Maunsell, first on the South Eastern and Chatham, and later on the Southern Railway, while the way in which Sir William Stanier carried the banner of Churchward triumphantly from Euston to John o' Groats needs no emphasis from us. The locomotives of Churchward's generic design will " see steam out " on the Western Region ; his dynamometer car and his stationary testing plant, both thoroughly modernised, have played a great part in recent locomotive development on British Railways. One day recently, when we were privileged to travel in that car and were witnessing a Churchward boiler steaming as never before, a senior member of the staff said : " Wouldn't the Old Man have loved this!" His spirit indeed lives on.

COMING CONFERENCE ON CLEAN AIR

At 7.30 p.m. ten days from now, on the evening of February 19, a Conference upon " The Mechanical Engineer's Contribution to Clean Air " will be opened at the Central Hall, Westminster, and an introductory address will be presented by Sir Ewart Smith. The Institution of Mechanical Engineers is to be congratulated upon organising this Conference. The Clean Air Act, 1956, became law in October last year. But many of its clauses do not become applicable until the Minister makes Orders bringing them into effect. As from December 31 last year those provisions relating to smoke control areas, new furnaces, height of chimneys and the appointment of Clean Air Councils have already become effective. Other provisions of the Act dealing with emissions of dark smoke, grit and dust will come into force, the Minister has already announced, early next year. But for seven years as from July 5, 1956—and only for seven years—it will be regarded as a good defence against any proceedings taken under the Act to show that, owing to the nature of a building or its equipment or the inescapable use of unsuitable fuel, though all is well maintained, the emission of dark smoke (defined as smoke which appears to be as dark as or darker than Shade 2 on a Ringelman chart) could not be avoided. It is worthy of note here that the Minister may by Regulation require recording and measuring apparatus to be fitted to furnaces and may require the records to be made available to the local authority concerned. Very possibly one of the provisions of the Act, that which provides that plans for the modification of a furnace or for a new installation can be submitted to a local authority for approval will lead to such submission becoming the general custom. The Act contains some simple provisions relating to dust and grit and its provisions apply to railway engines and in certain respects to ships. There is no need here to make reference to those sections of the Act which relate to the abatement of smoke from domestic chimneys, as the Conference will not be concerned with this aspect. But there are a number of references to air pollution resulting from industrial operations other than the straightforward combustion of fuels in furnaces. Under the Alkali Act of 1906 limitations are laid upon the discharge of noxious gases and under the Clean Air Act the Minister is empowered to make Orders adding to the list of works controlled under the Alkali Act. Very probably he will choose to bring under that Act all industrial processes in which technical difficulties in preventing the emission of smoke or noxious gases exist.

It will be observed that operators of existing furnaces now have just under 6½ years to modify the furnaces or install new plant so that fuel may be burnt without the emission of smoke, grit and dust. Some, of course, may be luckier. The operation of the Act is the responsibility of local authorities, and some no doubt will prove more enthusiastic in applying it than others. But in most industrial areas the local authorities seem already to have shown active interest. The Conference thus comes at an opportune time. The first session on Wednesday, February 20, is concerned principally with the smoke-free operation of industrial plant, but includes, we are glad to see, one paper on that very difficult problem (upon which the Clean Air Act has little bearing) the removal of sulphur dioxide from flue gases. Papers to be presented at the afternoon session deal with the particular problems of the iron and steel, ceramic, cement, and chemical industries and of foundries. On Thursday the problems of the coal industry and of preventing smoke emission from ships and locomotives are to be studied and consideration is also to be given to the problems of air pollution from road vehicles. Lastly, the very important matters of automatic control and instrumentation are to be surveyed and some study given to methods of educating and training boiler operators. The whole should make an instructive and timely survey of the problem, all the more timely that problems of preventing the emission of smoke are so closely allied to those of attaining economies in the use of fuel.

A Seven Day Journal

Chiswick Flyover

MR. HAROLD WATKINSON, Minister of Transport and Civil Aviation, has announced that the contract for the construction of the £820,000 two-level road junction at Chiswick, where the Cromwell Road extension joins the Great West Road, has now been let. Work will start within a few weeks. This projected road junction will incorporate a flyover half a mile long and a roundabout 400ft in diameter; besides serving as the junction of the Great West Road and the Cromwell Road extension, it will deal with traffic to and from the North Circular Road (Gunnersbury Avenue) and the Chiswick High Road. Some 40,000 vehicles a day use the present junction, which is seriously congested at times. The plans have been considerably improved, we are informed, since the scheme was first designed, and now incorporate a flyover, which will carry the Cromwell Road extension over the Wellesley Road as well as over the new roundabout, with the result that traffic travelling east or west will proceed without interruption from cross traffic. East-west traffic wishing to turn either north or south will use slip roads, each having a two-lane carriageway; the width of the carriageway around the roundabout will be 40ft. The flyover, which will be about half a mile in length, will be carried over the new roundabout by four spans, each of 125ft, and with a width between parapets of 59ft; this will provide for two lanes of traffic in each direction separated by a central island. The bridge over Wellesley Road will be 124ft between parapets, with four lanes of traffic in each direction. Each bridge span will have prestressed precast concrete beams, which, in conjunction with an *in-situ* concrete deck, will give a hollow slab construction. Other sections of the flyover, where it is not spanning existing roads, will be formed on embankments, the retained materials being confined by a concrete wall with brick facing. The area in which this flyover is being constructed is densely built, but the demolition of buildings, the Ministry states, has been kept to the minimum consistent with engineering requirements. The scheme is expected to take about 2½ years to complete, but traffic will be able to use the northern slip roads and most of the new roundabout within about twelve months. The new works have been designed by the consulting engineer, Mr. Harry Brompton, M.I.C.E.; the consulting architect is Mr. George Stewart, F.R.I.B.A.

Radio Communication and Electronic Engineering Association

THE annual luncheon of the Radio Communication and Electronic Engineering Association (R.C.E.E.A.) was held at Grosvenor House on February 1. Mr. C. H. T. Johnson, the chairman of the Association, who proposed the toast of the guests, referred to the remarkable expansion of the industry's exports in recent years. The total value of its exports was, he said, £40,000,000 last year, which was 20 per cent more than in 1955 and was twenty times as much as in 1938. Six years ago the industry anticipated that it would be able to make and install one marine radar set per day; last year it was installing these sets at the rate of five per day. Mr. Johnson referred to the formation by the R.C.E.E.A. of a data processing section, which was intended to serve the interests of firms concerned with electronic computers, data-handling and data-reduction equipment, automatic control systems, plotting equipment and digital telemetering systems. At the luncheon details were also given of some of the achievements of member firms. One, to which we have already referred in our columns, is the carrying out of tests, over 200 miles, of a tropospheric scatter system for multichannel communication. It is anticipated that complete links for carrying television channels or up to sixty telephone or teleprinter circuits will be available this year. Another is the development of a Doppler navigator, a self-contained device which operates independently of any ground-based station. It is being supplied to the R.A.F. and Commonwealth countries and a considerable field of application can be envisaged for it in civil aviation. A new "Commutated Antenna Direction Finding" system has been demonstrated; it operates in the h.f., v.h.f. and u.h.f. bands and it is stated to be subject to location errors only one-tenth the magnitude of those experienced with the Adcock system.

The Engineer
100 Years Ago
(FEBRUARY 6, 1857)

"THE DEARTH OF SKILLED WORKMEN"

"The fact is, we believe, undeniable, that, in every department of skilled labour but few are found who possess the highest degree of skill. There are, possibly, none amongst the employers of labour who have not, at some time or other, felt the inconvenience arising from this state of things. For some kinds of highly-finished workmanship it is extremely difficult to find a workman, and, when he can be found, he is too often not to be depended upon, either from his foolish independence or from dissipation. We believe it to be too general that, in proportion to a workman's skill, is his capriciousness and sensuality. Of course, there are honourable exceptions . . . .

"There can be no question that a better education must be given to our workmen ere they will be competent to grapple with the new fields of enterprising labour which are on all sides opening before them. And the education they require is not the mere meagre drilling in the common instruments of knowledge to which, in our wisdom, we have hitherto restricted their training. They must be educated sufficiently to form their tastes correctly, to open to them sources of purer pleasure, to lead them to invest their homes with the comforts and attractions that shall link them closely to them. They must be taught how to prize and enjoy pleasures that elevate in the place of those which debase. Further, they must be taught to think logically and consecutively, and must have enough knowledge of language to communicate what they know appositely and to receive instructions intelligently. And all this is perfectly and easily practicable. The means for its accomplishment to a large extent exist already and, where they do not, are capable of easily and speedily being called into existence . . . Let us honestly and earnestly do what we can to develop the powers and faculties of our people, by the medium of existing instrumentalities, or by the calling into existence new means if needed, and we believe we shall not have permanently to complain of a *dearth of skilled workmen.*"

Exhibition of Components Required by British Railways

IN order to carry out British Railways' programme for the fitting of continuous brakes to some 800,000 vehicles under the Railway Modernisation Plan, a vast number of components will be required from 1958 onwards, and the demand is expected to be beyond the capacity of the firms normally engaged in railway contracts of this kind. The British Transport Commission has, therefore, decided to widen its usual field of inquiries for the supply of the components. Many potential suppliers are not generally familiar with the components of the vacuum brake equipment concerned, and for this reason the Commission has arranged to hold an exhibition at which they will be shown. Firms interested will be able to inspect the components, together with their drawings and specifications, at the exhibition, so that they can decide in advance, with full knowledge of the requirements, if they can undertake manufacture of the parts. A majority of the components are steel, with a few iron and steel castings, and one or two light alloy and rubber components. The exhibition will be held in the Central Offices, Room 155, Euston Station, N.W.1, on Monday, February 18 (11 a.m. to 4 p.m.), on Tuesday-Friday, February 19 to 22, inclusive (10 a.m. to 4 p.m. each day), and during the corresponding hours on Monday to Friday, in the following week. It will not be open to the general public, and for the convenience of firms wishing to attend, admission will be by ticket only, obtainable on application to Mr. E. R. Sambridge, Chief Stores Officer's Department, B.T.C., Room 156, Euston Station, London, N.W.1 (telephone: Euston 1234, extension 8274). The date on which it is desired to attend should be stated, together with an alternative.

Institute of Refrigeration

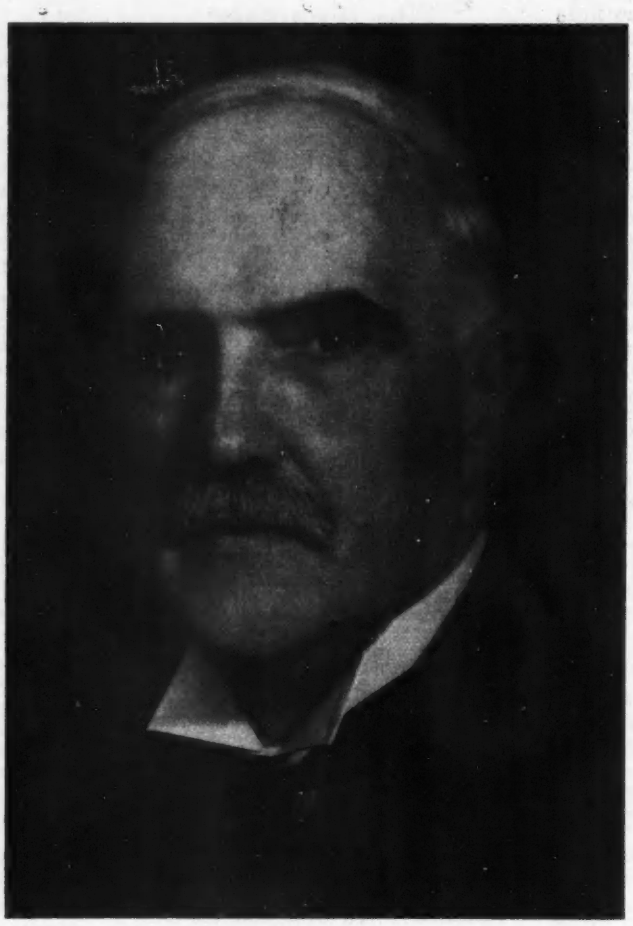
THE fifty-seventh anniversary dinner of the Institute of Refrigeration, which was attended by over 500 members and their guests, was held on Wednesday, January 30, at the Savoy Hotel, London, with the president, Lieut.-Colonel Lord Dudley Gordon, in the chair. Sir Hugh Beaver proposed the toast of "The Institute of Refrigeration" and commented upon the extent to which our production was dependent upon refrigeration, which served almost every industry and was in every home. He remarked upon the high standard required of those who aspired to membership and thought that the level of qualification must affect the number of members. However, he had a word of warning to say about too great a degree of specialisation and reminded those present that engineering was the largest source for providing men suitable for the highest level of management. The president replied and reported a further increase in membership and then went on to emphasise that knowledge of refrigeration did not necessarily mean being an engineer. However, the Institute did give support to the work of the National College for Heating, Ventilating, Refrigeration and Fan Engineering. Mr. A. O'B. Brandon proposed the toast of "The Guests" and commented upon the close association of the Institute with the armed forces and the government departments. He went on to appeal to the educationalists to pay attention to the development of the imagination of engineering students, which, he considered, was just as essential as a knowledge of mathematics for the solution of problems. He also thought it important for students to acquire the ability to criticise. Sir Donald Anderson responded.

Obituary

SIR JOHN CRAIG, C.B.E., LL.D.

SIR JOHN CRAIG spent the whole of his working life in the British iron and steel industry; his death, which occurred at Cambusnethan Priory, Wishaw, on February 1, less than a year after retiring from the eminent position he occupied for so long, is deeply regretted. He was in his eighty-third year, and his period of service with Colvilles, Ltd., and its predecessor extended over no less than sixty-seven years.

John Craig was born at Clydesdale, New Stevenston, on December 11, 1874. His father and his grandfather were employed in iron works, and at a very early age he began to gather some experience of the industry in which subsequently he became an acknowledged authority. A survey of his life's work, which was prepared last year by Mr. David Murray, records that John Craig, like other boys of his time, was in the habit of going into the works with meals for his father. In addition, there was an occasion when he earned a halfpenny for each of nine visits in a week carrying food to a hammer driver! John Craig left school just before his fourteenth birthday to become an office-boy at the Dalzell works of David Colville and Sons, as the firm was then entitled. It was a modest establishment consisting originally of twenty puddling furnaces and two mills, with four 12-ton open-hearth furnaces producing only about 500 tons of ingots a week. The whole plant in those days, it is said, occupied less than 14 acres, of which only 1 acre was roofed. But from David Colville and his three sons, the young John Craig gained excellent training in all departments of the plant as it then was; there he was inspired by those principles which undoubtedly influenced the many developments which he initiated and brought to fruition in the succeeding years. One of John Craig's jobs in his early years with Colville's was to keep the "Yankee slab book." The firm was busy shipping steel slabs for the first plates ever rolled in the U.S.A. At about the same time, John Craig was also concerned with the dispatch of the first steel plates built into an ocean-going liner in Germany.



Sir John Craig

In 1895, one of the Colville sons, John, entered Parliament, and on that account relinquished the regular representation of his firm at the Royal Exchange, in Glasgow. The task was one which was immediately entrusted to John Craig, who was then twenty-one. The daily journey to Glasgow by train, it is recorded, gave him the opportunity to continue the education which had been interrupted at the age of fourteen, and to expand it in directions which were not covered by his night-school curriculum. At the turn of the century, John Colville, who had become chairman of his company, died suddenly. It was an event which imposed a greater burden of responsibility upon the management, and resulted in John Craig taking a bigger share of that responsibility. He acquitted himself well, and in 1910 he was invited to become a director. A big expansion of the Dalzell works was put in hand in 1912, and shortly afterwards, of course, there came the first world war. For the first time since its formation, David Colville and Sons, Ltd., began to extend its interests outside Dalzell, by taking up a controlling share in the Fullwood Foundry Company; it was a venture to which John Craig gave particular attention. As the demands of the war intensified, the Government of the day asked Colvilles to become a focal point for the expansion of the iron and steel industry in Scotland. The Cambuslang works of the Clydebridge Steel Company were taken over by David Colville and Sons, Ltd., in 1915, and in the following year the Glengarnock plant was acquired, including the blast-furnaces and the Bessemer converters. For these developments, and others outside Dalzell, the main responsibility was ably shouldered by John Craig. David Colville and his brother Archibald both died within a few months of each other in 1916, and, at the age of forty-two, John Craig succeeded to the chairmanship of the company he had entered as an office-boy.

The 1920s turned out to be a difficult period for the British steel industry, but John Craig was one of those men who were convinced that its prosperity would return. He gave practical expression to that conviction, for during the time of depression his firm expended a considerable sum of money in the building of the Clydebridge plate mill. Moreover, his interest was not confined solely to his own company. There were many services which he unsparingly gave to the industry as a whole. He took a major share, for example, in the founding of the National Federation of Iron and Steel Manufacturers, and was one of its early presidents. In subsequent years, Sir John took a similar part in the establishment of the British Iron and Steel Federation, which succeeded the National Federation of Iron and Steel Merchants.

In the early 1930s, John Craig successfully steered his company to further achievements. The iron and steel industry passed through a period of reorganisation, and David Colville and Sons, Ltd., merged with other companies to form Colvilles, Ltd., which became a public company in 1936. By the time the second world war broke out, the firm was ready to meet the heavy demands that were made upon it. It was a state that had been reached in large measure through the foresight and energy of John Craig. It was fitting that his services to the nation and to the iron and steel industry should be recognised, first, in 1918 by the award of the C.B.E., and again in 1943 when the honour of knighthood was conferred. Another honour which he greatly prized was the award of the LL.D. degree by Glasgow University. When the second world war came to its end, Sir John did not seek the relaxation of retirement as many another of his years might have done. There was much that remained for him to accomplish. The development programmes of the iron and steel industry had to be launched, and the post-war developments of Colvilles, Ltd., were successfully under way before Sir John relinquished the responsibilities that he had so ably carried for such a long period. In March of last year, he decided that the time was opportune for him to retire from the offices of chairman and joint managing director of Colvilles, Ltd. It was a decision that evinced regret not only throughout the organisation to the building of which he had contributed so much, but also throughout the whole of the British iron and steel industry. From boyhood to age he had served that industry devotedly.

But no account of Sir John Craig's career could be complete without some reference to his many distinguished public services. From his youth he had always taken a great interest, and had been actively engaged in the work of the Y.M.C.A. He displayed a like interest in all aspects of industrial welfare, and a few years ago endowed the Craig War Memorial Home, at Skelmorlie, on the Firth of Clyde. He was also a Deputy Lieutenant and a Justice of the Peace in the County of Lanarkshire. Finally, there was his work for the Iron and Steel Institute and for the West of Scotland Iron and Steel Institute. He served both bodies as president, his presidential years of the Iron and Steel Institute being the difficult ones from 1940 to 1942.

In all these public services, as in the daily concerns of his business, Sir John revealed not only ability but ready sympathy and understanding. They were traits which endeared him to the many who worked with him and were in any way associated with him during a long life that was well spent.

Comparison of Continental, Russian and British Engineering Education

By C. JAEGER, Dr. ès. Sc.,* B. L. GOODLET, O.B.E., M.A., M.I.Mech.E.,† and A. L. L. BAKER, D.Sc., M.I.C.E., M.I.Struct.E.‡

No. I

In this group of contributions by three authors, Dr. Jaeger first reviews higher technological education on the Continent, drawing attention to entry requirements into universities and colleges, to the nature and length of the courses that follow, and to the advanced studies that can be added later. Reference is also made to the work of the teaching staff. There follows a short comparative study by Professor Baker between British and Continental methods. A section on Russian engineering education by Mr. B. L. Goodlet comes next, in which the history of Russian scientific education is briefly noted and particulars are given of present methods and comparisons made between this country's and Russian methods. Lastly, Professor Baker sums up, drawing the conclusions that in this country post-graduate courses should be expanded, more boys should be recruited from schools for education in engineering, and that the status of professional engineers needs to be raised.

HIGHER TECHNOLOGICAL EDUCATION ON THE CONTINENT

By Dr. C. JAEGER

Entry Requirements

ALL over Europe a certificate is required for entry into any technical university. It is called "Baccalauréat" in France, "Maturité" or "Baccalauréat" in Switzerland, "Reifezeugnis" in Germany and Austria, "Maturità" in Italy. In most countries the same certificate is required for entry into any university faculty.

The standard of the Swiss Federal "Maturité" is about the same as the Advanced Level General Certificate of Education. The number of compulsory subjects includes four languages—the student's mother tongue and three others, which may be classical or modern. In Latin, the standard is definitely higher than the O.C.S.E.B. "Latin taken early examination," or the ordinary level certificate, and the curriculum for foreign modern literature is extensive. Other subjects required are mathematics, including the elements of differential and integral calculus; physics, chemistry and biology; history and geography. Several Swiss secondary schools award slightly different certificates, greater emphasis being placed either on science or on the Classics.

For those students who do not possess a "Maturité" or "Baccalauréat" Certificate, there is a special entrance examination into the Federal Institute, more or less equivalent to a "Maturité," possibly slightly easier. This entry procedure is followed by students from technical schools, who, perhaps after several years of practical experience, want to join the institute. For entry into the Faculty of Mechanical Engineering, a nine-months' workshop apprenticeship is required before admission to the Institute.

The standard of the German, Italian and Austrian entry requirements are similar to the Swiss ones. The French "Baccalauréat," which is taken in two sessions, is more specialised than the Swiss "Maturité." There is a choice of five main syllabuses. A typical course, leading to the higher technical schools, includes, in the first session, a written examination paper in French, Latin and mathematics, including the first elements of calculus, and a paper on physics and chemistry or on a modern language. Then follow oral examinations in French literature, Latin, history nad geography, mathematics, physics and chemistry, and one modern language. A year later, the second session will take place and include papers on philosophy, mathematics and the sciences, and oral examinations in the subjects taken at the first session, supplemented by an oral examination in philosophy.

The other syllabuses lay greater stress on either the humanities or scientific subjects. The "Baccalauréat" allows the student to enter any French university and almost all of the technical schools. However, it is not sufficient for admission to "Les Grandes Ecoles," i.e. Ecole Normale, Ecole Polytechnique, Ecole Centrale, Ecole des Ponts et Chaussées, Ecole des Mines. The Ecole Supériéure d'Electricité and a few others admit a limited number of candidates after special examination.

The examinations for entry to the Ecole Polytechnique are typical of French conditions. The great Henri Poincaré almost failed to pass! To prepare for this examination, students have to spend an additional three years at the Lycées: only 2 per cent of the candidates pass after two years' preparation. The syllabus in mathematics and science is slightly above the standard of the Cambridge scholarship papers in the natural sciences. A detailed knowledge of the theory of mathematical functions is required. In 1951, 1559 candidates attended the examinations, and only 226 passed, of whom only thirty-five had two years of special preparation. Many of those who fail try again at other Grandes Ecoles and obtain entry.

Standard of Education at Continental Technical Universities

Common Courses in Mathematics, Physics and Mechanics.—Most of the Continental technical universities require students to spend the first two years, out of a total of four or five, on common courses in mathematics and the sciences. A comparative study of the syllabuses for Zurich, Milan and Vienna shows that they cover almost identical ground. The Politechnico di Milano has a two years' course common to all the Faculties with the exception of architecture. The lectures on mathematics and the sciences are supplemented by courses in general technology, and attendance is compulsory.

Considering the courses at the Swiss Federal Institute of Technology a little more in detail, the two first years are mainly concerned with mathematics, geometry, physics, mechanics, strength of materials and structures; some specialised courses on structures, geology and surveying are included at this stage for students of civil engineering, and lectures on machine design and machine technology, hydraulic machinery and elements of thermodynamics are provided for mechanical engineers, and, in addition, the elements of electro-technology for electrical engineers. In addition to the compulsory part of the syllabus, the student has a wide choice of supplementary lectures on higher mathematics and physics. The syllabus at Vienna Technical University is similar to that of Zurich, but probably with less freedom in optional subjects.

Comparing these first two years at the Swiss Federal Institute with the syllabuses at other universities, the number of hours for the compulsory lectures and exercises in mathematics, geometry, mechanics and physics are:

Moscow Higher Technical Institute ...	966
Zurich...	1011
Vienna	996

This table applies only to compulsory lectures.

According to Mr. Goodlet, the Russian student has no calculus at entry, whereas the Swiss, German, and Austrian students will have studied the elements of calculus for one or two years.

A very high standard is attained at the French Grandes Ecoles, which might be expected after the very severe entrance examinations. The Ecole Polytechnique de Paris has a world-wide reputation for giving the toughest possible training in a two years' course, mainly centred on mathematics and physics. An analysis of the syllabus of the Ecole Centrale shows that it is also very thorough in the basic subjects, mathematics and mechanics. At these schools, the whole syllabus for mathematics and the sciences is compulsory for all the students, whereas at other European schools some more advanced parts of the same syllabus are recommended, but without being compulsory.

Technological Studies.—Diverging trends are noticeable in the technological syllabus of the Continental technical universities. They are partly explained by the past history of the schools, their development, environment, and also to a large extent by the kind of engineers they want to produce.

The Ecole Polytechnique de Paris is a military boarding school founded in 1794 under Napoleon by Monge for training artillery officers and engineers. Field-Marshal Joffre and General Gamelin were former students of this school. To-day, the school produces the higher technical staff required by the Government and industry. After a two years' course concentrating on mathematics and physics, the students take a further two years' training at either the Ecole des Ponts et Chaussées (for civil engineers) or the Ecole des Mines (for mining engineering), or the Ecole Supérieure d'Electricité, or enter the treasury, the army, or one of the ministries. A small number go straight into industry. The Ecole Polytechnique is not so much an engineering school as a preparatory school for other big technical schools. It claims to have produced some of the finest experts in the fields of science, mathematics, finance and literature, as well as engineering.

The Ecole des Ponts et Chaussées accepts every year twenty-five French and six foreign students. Most of these enter the school direct for a three years' course, a few come from the Ecole Polytechnique for a two years' course. The school is supposed to train civil engineers for the French ministries but many students go into industry. The former students of the school publish a three-monthly journal, and judging by the

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‡ Dean of Faculty of Engineering, University of London, Professor of Concrete Technology, Imperial College.

quality of the papers, there is no doubt that the standard of the school is extremely high and is deserving of its world-wide reputation. The Ecole des Mines, also a state school, is similar to the Ecole des Ponts et Chaussées with a programme centred on mining engineering. The Ecole Supérieure d'Electricité is a private school.

The Ecole Centrale, Paris, has a different purpose. This school's aim is to train all-round engineers of the highest ability, and the nearest approach to its syllabus in Great Britain is the honours degree course in the mechanical sciences at Cambridge University. The lectures are compulsory for all students who specialise in one of four main subjects during the third and last year.

Examinations at the Ecole Polytechnique are held half-yearly on all the subjects ; this is in addition to numerous written exercises, mainly in mathematics and the sciences, but also in history and French literature.

The final examination at the Ecole Centrale has a more practical slant. The students are allowed one month to produce a detailed project and sit twice for five hours to prepare two additional projects. They are required to discuss these three papers in an oral examination. This final examination is preceded by two examinations at the end of the first and the second year.

It must be emphasised that France possesses a great number of other technical schools giving technical education at different levels from the upper grammar school standard up to high university standard. As examples, the technical university for hydro-power engineers at Grenoble and the Institut Electrotechnique, Toulouse, have world-wide reputations.

Technical universities in Germany, Austria and Italy show a different approach to technological teaching. The Swiss Federal Institute of Technology is typical. As already explained, students concentrate on common courses with a few specialised subjects during the first two years. Specialisation does not really begin until the third year and is increased in the fourth year. Mechanical engineers specialise more in the third year than civil and electrical engineers. Thus the total course takes four years and the final examinations take up an additional three months. The Institute has eleven Faculties, viz : Architecture, Civil Engineering, Mechanical Engineering, Electrical Engineering, Chemistry, Pharmacy, Forestry, Agriculture, Surveying, Mathematics and Physics, Natural Sciences, Military Faculty. The twelfth Faculty is for general studies ranging from philosophy and arts to law, sports, biology and military exercises. Special lecture courses are arranged on aeronautics, meteorology, metallurgy, &c. There is an examination (Vordiplom) after the first year on mathematics and geometry, and after the second year on applied mechanics, physics and some technical subjects.

For the final diploma the students are required to specialise in such subjects as turbo-machines, textile machinery, aero-engines, bridges or hydro-power, and so on. The written examination consists of a detailed project with drawings and calculations, for which the students are given six weeks. Many of these projects are of excellent standard. A similar specialisation exists with regard to the final subject at Vienna Technical University and, to some extent, at Berlin. The syllabus of the Politechnico de Milano is definitely less specialised, a tendency which was already made clear by the arrangement of the syllabus for the first two years of studies.

Studies at the Ecole Centrale de Paris have been compared with the honours course in mathematical sciences at Cambridge University. Zurich diploma courses may be compared to undergraduate followed by post-graduate courses at the Imperial College, London. After passing the Baccalauréat or a similar examination the duration of the studies is :—

Four years plus three months for the diploma at Zurich ;

Four and a half years plus diploma examination at Berlin and Vienna ;

Five years at Milan ;

Five years for the Ecole Centrale, Paris, (including three years' preparatory training after the " Baccalauréat ") ;

Seven years for the Ecole Polytechnique and the Specialised School which normally follows, also including three years for preparatory training.

Policy with Regard to General Studies

In order to counterbalance the specialised technical training, general studies are favoured at most Continental technical universities. The regulations of the Ecole Polytechnique de Paris provide for additional marks at the entrance examination for Latin and for Greek previously taken at the Baccalauréat and for foreign languages taken at the entrance examination itself. The syllabus of the lectures at the school includes, as compulsory subjects in the final examinations, the history of the world from 1830 to the present day, modern French literature, social studies, economics, and two foreign languages. At the Ecole Centrale, accountancy, law and economics are listed in the syllabus as compulsory subjects.

A notable feature in the new syllabus of the Technical University of Berlin-Charlottenburg is the inclusion of philosophy, history of arts, and of music, biology, law, economics, higher administration, history of technology and of physics, geography, classical and modern languages in the so-called First Faculty. Three subjects of this Faculty are compulsory and must be taken before the first technical examination. Furthermore, an examination in four general subjects must be passed before the student is admitted to the final technical examination. The Technical University of Berlin stresses in its prospectus the importance attached to general studies.

The Twelfth Faculty at Zurich is no less important than the First in Berlin. The lectures cover the same subjects and the standard of some of them is extremely high. For many years the world-famous Professor Jung was teaching philosophy and psychology, while Professor Gonseth is still lecturing on the philosophy of sciences and mathematics in this faculty. Attendance to at least one course of lectures per term is compulsory. Examinations may be taken, but with few exceptions (law) are not compulsory.

Two modern languages, law and economics are compulsory subjects at the Politechnico di Milano.

The Professorial and Teaching Staff

The list of past and present professors and tutors at the Ecole Polytechnique de Paris contains some of the most famous names in the fields of mathematics and physics in France. The teachers at the Ecole des Ponts et Chaussées are former students of the school, some of them being entrusted with important administrative responsibility. The lecturer for dam design is Monsieur Coyne, consulting engineer to Electricité de France ; the lecturer for hydraulic structures and internal navigation is Monsieur Aubert former chairman of the Compagnie Nationale du Rhône, in charge of the hydro-power equipment for the whole Rhône Valley. The lecturer for fluid mechanics was Nizery, former Director of the National Research Laboratory of Chatou. Teachers at the Ecole Centrale are mainly former students of the same school, many of them carrying personal responsibilities in industry.

In France, being a professor at one of the Grandes Ecoles is often a part-time job. On the other hand, teachers at the technical universities of Berlin, Vienna and Zurich are mostly full-time professors and occasionally directors of research laboratories. Many of the professors at these universities are engineers with wide practical training and administrative responsibility in their own profession, and there are only a few teachers with purely academic training in the engineering faculties.

A professor at the Federal Institute is expected to keep in close touch with industry and to be able to give expert advice in his own particular field. He is not allowed to have a private consulting practice, but is permitted to use the facilities of the school to conduct investigations and to advise outside bodies.

Professors of all nationalities are found in Zurich.

Advanced Studies and Theses

No research work or advanced studies are carried out at the French Grandes Ecoles. This type of work is done at the French universities or in numerous State-owned or private laboratories. German and Swiss technical universities, however, are famous for the advanced research work they encourage. The background of the professors, their connection with industry, and their personal interest have a direct bearing on the advanced research studies and on the theses presented for higher degrees. Two hundred copies of any thesis must be presented to the library of the Swiss Federal Institute, and about a hundred to the Berlin Technical University. To cover his expenses the candidate therefore endeavours to have his thesis published by a technical journal or printed as a book. Financial considerations therefore tend to make candidates restrict their choice of subject to problems with a direct technical interest. Excellent research work is being done and published in all countries through this system.

(*To be continued*)

Hydrophobic Cement

We are informed that a hydrophobic cement has been developed by the Blue Circle group. The Cement Marketing Company, Ltd., states that the new product, which is known as " Hydracrete," is intended for use in conditions which would be unfavourable for the storage of normally packed ordinary Portland cement and on sites where consignments cannot be fully used during storage periods reasonable for ordinary Portland cement. The physical requirements of B.S. 12 : 1947, for ordinary Portland cement, are met by the new product. It is stated that for many years the company has marketed " Aquacrete," a water-repellant cement, and " Hydracrete " is a logical development in which the capacity for longer storage in damp conditions without deterioration to any marked degree has been accentuated. It is claimed that concrete strengths equal to those obtained with ordinary Portland cement can be obtained with " Hydracrete," which also imparts its water-repellant properties to concrete made with it. The company states that " Hydracrete " requires slightly more thorough mixing than ordinary Portland cement if the full benefits of normally strong and water-repellant concrete are to be obtained.

Traction-Engine Railway Locomotives

By R. A. S. ABBOTT

No. II—(*concluded from page* 168, *February* 1)

ABOUT 1893 a demand was evidently felt for a more powerful geared locomotive for industrial work, so a four-coupled design was produced by Aveling and Porter with two cylinders arranged on the compound principle and based on the firm's 1892 patent as applied to road traction engines. Rectangular slide bars were replaced by trunk cross-head guides and a valve was provided to admit steam at boiler pressure to the low-pressure cylinder when starting.

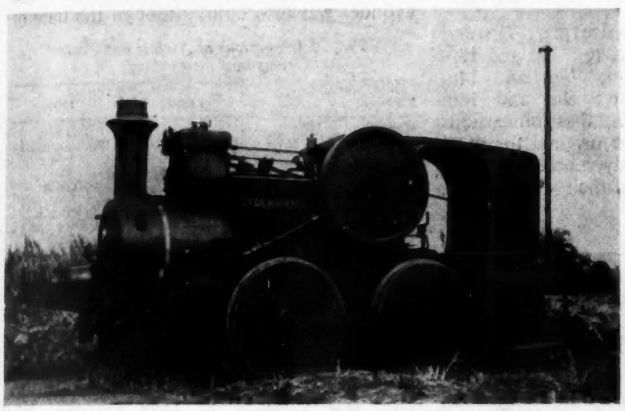
These locomotives were a great advance on previous designs, having a short wheel base, could be run at almost twice the speed, and possessed a much greater haulage capacity. The locomotive illustrated in Fig. 13 was built in 1896 (Works No. 3567) for W. Cory and Sons, Erith, and shows how the valves in this first compound design were placed on top of the cylinders, but after a few years the arrangement was altered to one in which the valve chests were placed at the sides, giving greater accessibility. This difference will be readily seen on examination of Fig. 14 which is an illustration of a 4ft 3in gauge locomotive built in 1899 (Works No. 4414) for Lees Cement Works, Halling, and Fig. 15 which shows a locomotive built in 1901 (Works No. 4780) for Croydon Gas Works, and of 4ft 8½in gauge. The drive was by gearing on the right-hand side, a pinion on the crankshaft engaging with a large spur wheel fixed on a stud shaft, and this spur wheel served to drive both axles through gear wheels fixed on the inside of the flanged wheels. The gear ratio was usually 3 to 1. All locomotives of this type had a stay-rod between the axles, and, except for the very early ones with solid disc wheels, wheels with a form of H section spokes were adopted. For gauges narrower than about 4ft, the gearing was located outside the wheels and Fig. 16 illustrates this variation, the locomotive being "Progress" (Works No. 6040 of 1906), built for the 3ft 5½in gauge with the wheel flanges outside the rails, and was one of six similar locomotives supplied between 1897 and 1908 to the Swanscombe Cement Works situated between Dartford and Gravesend. Quite a number of these locomotives were fitted with all-over cabs extending to the rear of the coal bunker; viewed from the side they appeared quite commodious with their oval side windows and curiously shaped entrances, but they were in reality narrow, and anyone who has examined the footplate of a traction engine or steam roller will realise what a small space there was. Several locomotives of this class were spring mounted and had splashers and running boards like the "Eric," Fig. 19, built in 1914 for Sheffield Gas Works (Works No. 8372).

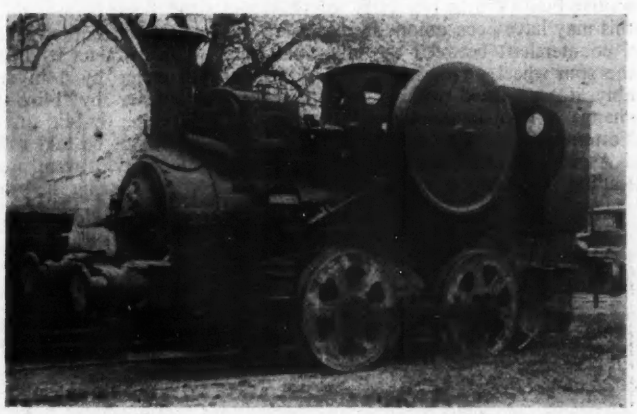
A locomotive possessing several unusual features was built for the old Cammell, Laird works at Sheffield, in 1919 (Works No. 8994), and is illustrated in Figs. 17 & 18.

The rear half of the cab was omitted, and a winch fitted on the stud shaft for handling hot armour plate, guide pulleys being located fore and aft. This winch was driven by a separate pinion and gear wheel, which appears to have been arranged in such a way that the locomotive could either move along the track while winding in or paying out the cable, or by sliding the crankshaft pinion to the right, the winch only was operated. When not in use the winch was disengaged by a dog-clutch.

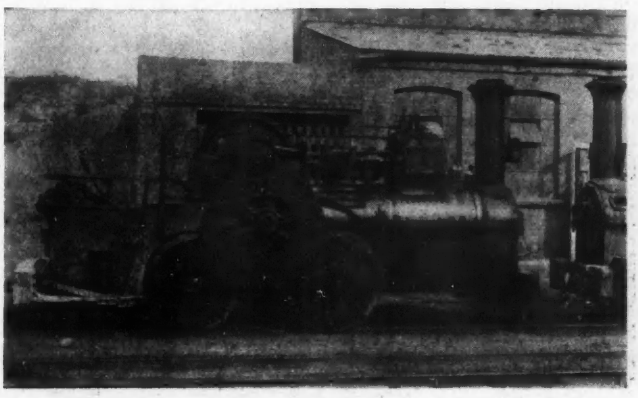
Details of this winch can be seen in the rear elevation of this locomotive, Fig. 17, which also serves to show the form of spring mounting which was employed on some of these four-coupled locomotive designs. The final-drive spur wheels were mounted on large diameter hollow stud bearings rigidly bolted to the frame and large enough for the spring-mounted axles to pass through with room for a small amount of vertical play.

Between the spur wheels and rail wheels were floating rings which transferred the drive from the spur wheels to the rail wheels by means of projections which engaged with slots in two of the wheel spokes and in similar slots at right angles in the spur wheels. This "Oldham" coupling was first adopted about 1899.

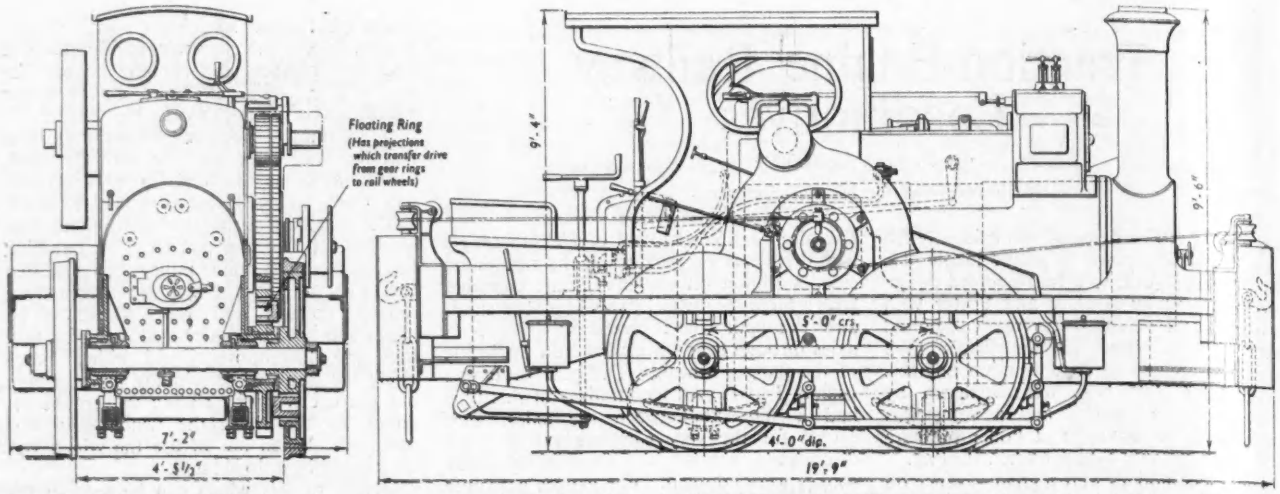




Figs. 13 and 14—(Left) Early compound locomotive built in 1896 for W. Cory and Sons, Erith. (Right) Narrow-gauge modified compound locomotive built in 1899 for Lees Cement Works, Halling



Figs. 15 and 16—(Left) Compound locomotive built in 1901. The "Allen Lambert" for Croydon Gas Works. (Right) Narrow-gauge compound locomotive "Progress," built in 1906 for Swanscombe Cement Works



Figs. 17 and 18—Class "TCFD" spring mounted compound locomotive built by Aveling and Porter in 1919 for Cammell, Laird and Co., Sheffield, and fitted with a winch for handling hot armour plate. (Left) Rear view of locomotive showing "Oldham" coupling between spur wheel and rail wheel. (Right) elevation of the locomotive

In Fig. 20 is illustrated what is believed to have been the last Aveling and Porter locomotive built (Works No. 11087 of 1924) and this may have been unique in that there was a countershaft between the crankshaft and the spur wheel on the stud shaft. Presumably it was fitted with a two-speed gear change. This locomotive worked at the Totternhoe Lime Company, Dunstable.

As with the single driving wheel type the leading dimensions were varied to suit different requirements. Two sets of dimensions are listed as typical examples in the table below.

Other recorded cylinder sizes are : 7½in and 12in diameter by 14in stroke ; 8in and 13in diameter by 14in stroke ; 7½in and 14in diameter by 14in stroke ; 9in and 14in diameter by 14in stroke, but these dimensions must not be taken as the original for most locomotives were probably rebored at some period during the years of their working life.

A class of locomotive generally similar to the above compounds but with only one cylinder was also built, although the date of introduction is not known to the author. One was supplied in 1899 (Works No. 4430) to T. G. Pascall and Sons, Ltd., Borough Green Brickworks, Kent, for the 4ft 8½in gauge and with 2ft 11in wheels. An official photograph of this class exists, but it has not been possible to reproduce it here. The total number of locomotives produced by Messrs. Aveling and Porter is now known to have been very much larger than was formerly supposed, and 105 examples have been traced.

Typical Dimensions of Aveling and Porter compound locomotives

Date	1899	1906
Gauge	4ft 3in	4ft 8½in
Cylinders	8½in and 14½in by 14in	10in and 16½in by 14in
Wheels, diameter	3ft 6in	4ft
Wheel base	—	5ft 0½in
Flywheel, diameter	—	4ft
Normal speed	5 m.p.h. (at 150 r.p.m.)	5·6 m.p.h. (at 130 r.p.m.)
Steam pressure	160 lb	180 lb
Tubes	76 of 1¾in dia.	100 of 1¾in dia.
Total heating surface	199 sq. ft	257 sq. ft
Grate area	6·8 sq. ft	8·75 sq. ft
Boiler feed	One pump and one injector	Two injectors
Water capacity	—	217 gallons
Coal capacity	—	7½ cwt.
Weight	13 tons 9 cwt.	—

In 1867 Messrs. Clayton and Shuttleworth, Stamp End Works, Lincoln, supplied to Messrs. Hall and Company of Croydon, the unusual locomotive shown in Fig. 21. It had two cylinders 7½in diameter by 12in

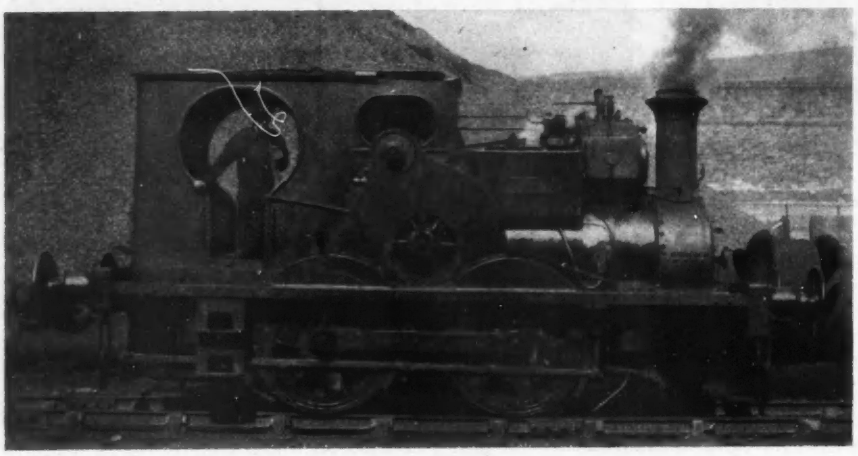
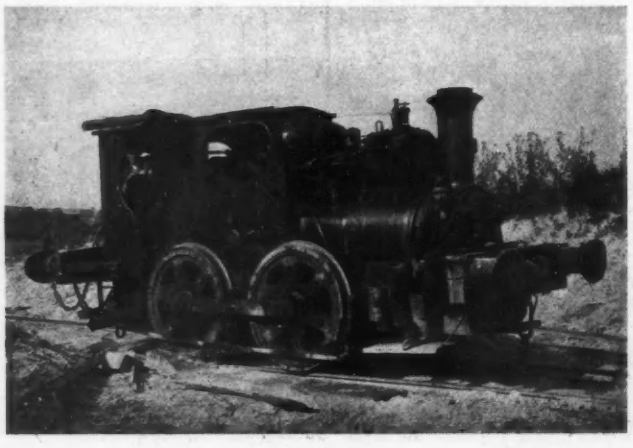


Fig. 19—Spring-mounted compound locomotive, "Eric," built in 1914 for Sheffield Gas Works



Figs. 20 and 21—(Left) Compound locomotive built in 1924 for Totternhoe Lime Company, Dunstable. (Right) Clayton and Shuttleworth locomotive built in 1867 for Hall and Co., Croydon

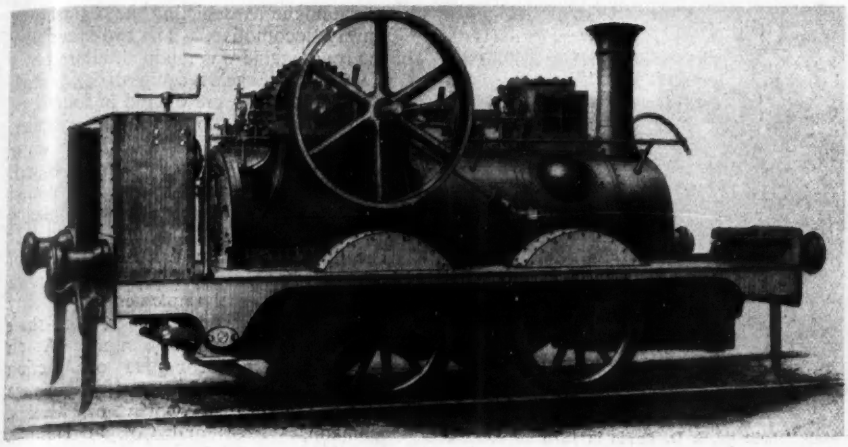


Fig. 22—Ruston, Proctor locomotive built in 1869 for service on the Continent

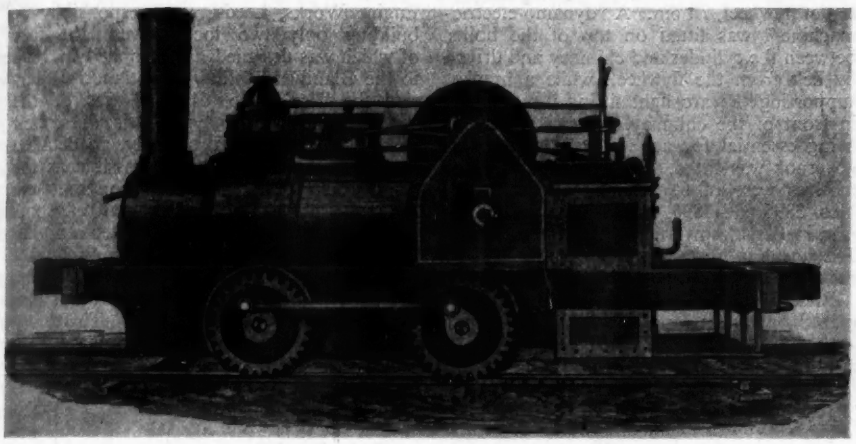


Fig. 23—Narrow-gauge locomotive built in 1874 for the London Lead Mining Company, Middleton-in-Teesdale

stroke ; driving wheels 3ft and ¾in diameter, single chain on right-hand side driving on to the leading and trailing axles, the sprocket wheel on the crankshaft having five teeth and those on the axles fifteen teeth. The wheel base was 9ft, frame of timber, total length of engine 17ft 6in. The boiler contained thirty-four tubes 2¼in diameter, total heating surface of tubes and firebox 170 square feet, grate area 5·4 square feet.

This locomotive was evidently an adaptation of the firm's 10 n.h.p. double-cylinder agricultural traction engine of the period. A woodcut of this type of locomotive from an early catalogue is reproduced on page 14 of R. H. Clark's recent book *Steam Engine Builders of Lincolnshire*, so it seems probable that several were built. Messrs. Clayton and Shuttleworth also built a few orthodox locomotives of the 0–4–0 inside cylinder saddle-tank and 0–4–0 outside cylinder frame tank types.

The firm of Ruston, Proctor and Co., Sheaf Ironworks, Lincoln, appears to have produced only one locomotive of traction engine type, although locomotives of orthodox design were turned out in small numbers.

This odd locomotive was constructed in 1869 to the designs of a Mr. John Pinchbeck and is illustrated in Fig. 22. It was intended for service on the Continent, and to take a load of 25 tons up an incline of 1 in 20 for a distance of 3 miles. The cylinder was 10in diameter by 12in stroke, wheels 3ft 6in diameter on a base of 4ft 9in. The firebox was flush with the boiler, the barrel of which was 3ft diameter by 6ft 8in long ; fifty-three tubes, 2¼in diameter, gave a heating surface of 250 square feet, grate area 5·2 square feet, steam pressure 60 lb per square inch, coal capacity 11 cwt, total weight 12 tons. The two-speed gearing gave rail speeds of 2 m.p.h. and 4 m.p.h., and the wheels were coupled by side rods.

In the mid-nineteenth century at Poole in Dorset, a well-equipped engineering works was owned by a Mr. Stephen D. Lewin, a gentleman of considerable wealth, who is said to have run his business more as a hobby than for profit. Whether this be true or not, the firm certainly did a very diverse trade, and during the eighteen-sixties and eighteen-seventies built thrashing machines, portable and fixed steam engines, locomotives and high-speed steam launches.

Although the number of locomotives built was not very large, the variation in design was such that hardly any two were alike, and the author has fourteen photographs and engravings of locomotives by this firm and each one is of different design, four being of traction engine type. The illustrations Figs. 23 and 24 are of a very small locomotive of only 2½ n.h.p. and 2 tons 12 cwt in weight, built in 1874 for the 22in gauge mineral lines of the London Lead Mining Company, at Middleton-in-Teesdale. There would seem to be no obvious use for the spur wheel on the front axle other than acting as a spare for the rear driving axle. An advertisement of the period states that these spur wheels were of steel and it is probable that the wheel, flange and toothed ring, formed one casting.

A photograph of another locomotive of this kind, carrying the name "Lindholme," and built for a much wider gauge, appears in an article in the *Railway Magazine* for April, 1934, pages 266–270. It had the gearing on the right-hand side, placed inside the wheels, and with the flywheel on the left-hand side ; the disc wheels had four circular holes.

In 1876 Messrs. Guinness ordered two small locomotives of traction engine type for use on their 22in gauge lines at the famous St. James Gate Brewery, Dublin, and in Fig. 25 these locomotives, "Hops" and "Malt," are shown standing in the maker's yard before delivery. It will be seen that the gearing is placed on the right-hand side with the flywheel on the left, and it is understood that the height to the top of the cylinder was only 3ft 6in and to the top of the chimney 4ft. One of the locomotives was scrapped in 1914 and the other in 1927. It is a matter of regret that, in spite of the number of illustrations of Lewin locomotives extant, so few dimensions are available.

The name of John Fowler and Co., Leeds, is primarily associated with the development of the steam ploughing engine, together with the traction engine and road roller, but among the 22,000 engines of all kinds built between 1857 and 1935 were a large number of railway locomotives of many kinds. It is unfortunate that no official records of railway locomotives built before 1896 now exist, except large albums of photographs, but from many outside sources over 200 have been traced, and of these thirteen were of the traction engine type, and the few details that are known about them are appended here.

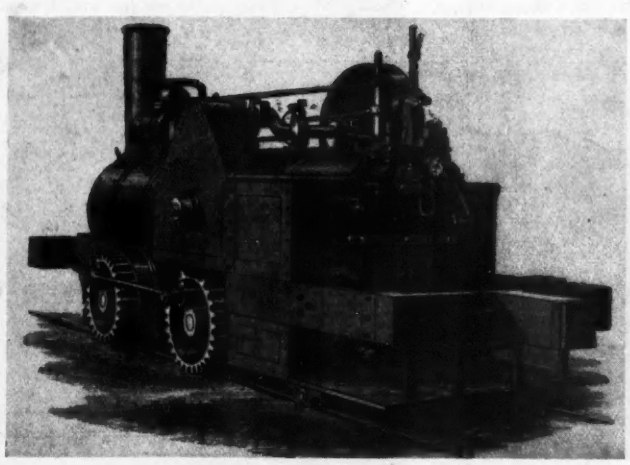


Fig. 24—Narrow-gauge locomotive built in 1874 for the London Lead Mining Company, Middleton-in-Teesdale

In 1874 a four-coupled locomotive was built for Cory Bros. and Co., followed in the same year by two similar ones with 8in diameter cylinder for Guest, Keen and Nettlefold at Dowlais, and in 1875 by one with a 6½in diameter by 12in stroke cylinder, also for Dowlais. One locomotive went to Pentre Colliery, Pontypridd, in 1874, while one was exported in 1875 to A. Hemmingway in Havana ; this latter had a 6½in diameter cylinder. A single driver type was built in 1880 for J. W. Marin, Auckland, N.Z. The

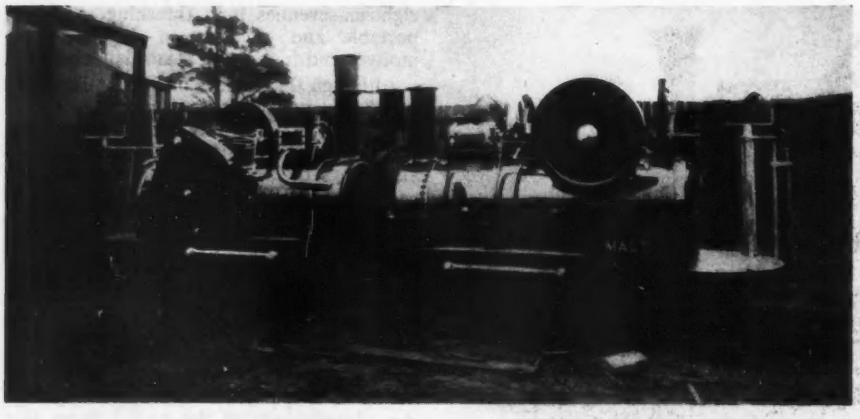


Fig. 25—Narrow-gauge locomotives "Hops" and "Malt," built by S. D. Lewin in 1876 for Messrs. Guinness, Dublin

author has not been able to determine whether the above locomotives were single or double-cylinder machines.

About 1888 three four-coupled locomotives were supplied to the Bearpark Coal and Coke Company, near Durham, to work on the elevated 3ft gauge line serving the coke ovens. Fortunately, a photograph of one of these has survived and is reproduced here in Fig. 26.

For many years Messrs. Fowler used a four-coupled compound engine, named "Lion," as their works shunting locomotive at Leeds, and this is illustrated by Fig. 27. The front axle was supported on half-elliptic springs, but whether the rear axle was sprung is not known. The woodcut, Fig. 29, shows the single-driver type and this particular locomotive is understood to have been supplied for military use, although a generally similar one was built for the London County Council in 1896.

The locomotive shown in Fig. 28 was one of two built by Ransomes, Sims and Head, Orwell Works, Ipswich, in 1879, and was designed with the idea of meeting a desire felt at that period by railway officials and contractors for an improvement in the imperfect arrangements used for lighting-up works on the permanent way at night, for the examination of the linings of tunnels and similar purposes. The locomotive was of light construction mounted on four flanged wheels and fitted with a two-speed gear train, giving rail speeds of 1 m.p.h. to 2½ m.p.h.

No official dimensions are now available, but the following measurements are approximately correct: driving wheels, 3ft 11in diameter; leading wheels, 2ft 5in diameter; flywheel, 4ft 2in diameter; overall length, 16ft 3in; overall width, 5ft 9in; height to top of flywheel, 7ft 6in. A "dynamo-electric-machine" was fitted on top of the boiler between the cylinder and chimney and driven by belt from the flywheel, while a bracket supporting the arc light fitting was secured in front of the chimney. A steady current being essential for an arc lamp a sensitive governor was fitted. The above two locomotives were of 6 n.h.p. and bore Works Nos. 3895 and 3896, and were supplied to a firm in Paris known as the Société Indienne. The agent in the transaction was a person named Dollfus.

Richard Hornsby and Sons, Ltd., Spittlegate Ironworks, Grantham, adopted their agricultural road engine to run on rails, and the engraving, Fig. 30, is described in an early catalogue as depicting the "Improved Tramway Locomotive." The two-speed gear of the road engine was retained, altered by a single lever, the gears being of cast steel. These locomotives were offered in four sizes, 6, 8, 10 and 12 n.h.p., with one cylinder. It will be noticed that an auxiliary water tank was carried under the boiler barrel. No official records exist to indicate the period during which such engines were being built.

The firm of William Weeks and Son, of Maidstone, Kent, are perhaps better-known for their agricultural implements, but they did build a few single-cylinder, four-shaft traction engines of about 6 n.h.p. At an unknown date a locomotive of traction engine type was built for the 4ft 2in gauge lines at the cement works of Messrs. Trechmann, Weekes and Co., at Halling, Kent. This was of 2–2–0 wheel arrangement and bore the name of "Lioness."

Messrs. J. and H. McLaren, Midland Engine Works, Leeds, were responsible for building only two locomotives, the first of which was designed and supplied in 1896 to the Glanlivet Distillery, Scotland. It carried the Works No. 614 and was of the single driving wheel type; it is illustrated here in Fig. 32. Unfortunately, no detailed description of the engine is possible as the maker has informed the author that the original drawings were disposed of some years ago. Nineteen years later another locomotive was built, Works No. 1547, of 1915, this time for Messrs. Hall and Co., Croydon, and bearing their No. 9. It was of the four-wheel coupled type. This locomotive, Fig. 31, should be compared with the Clayton and Shuttleworth locomotive,

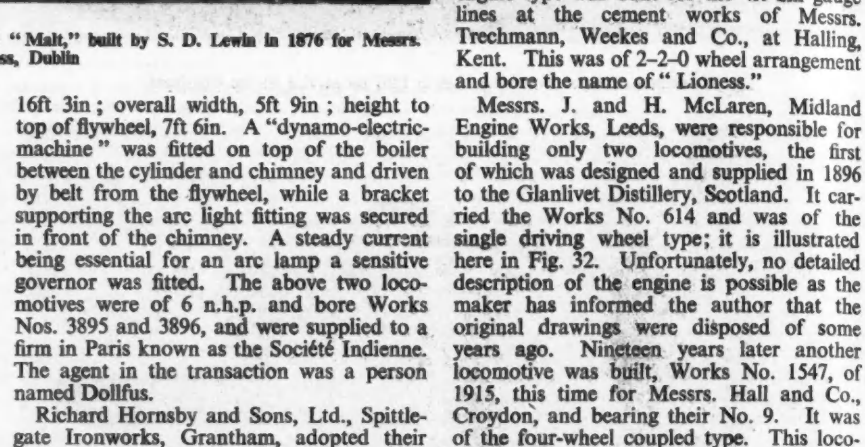
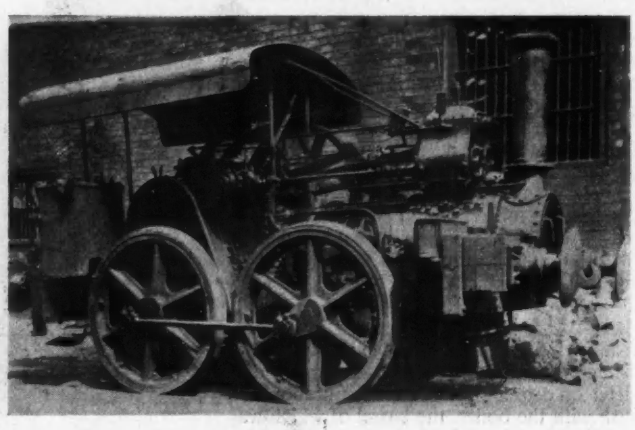
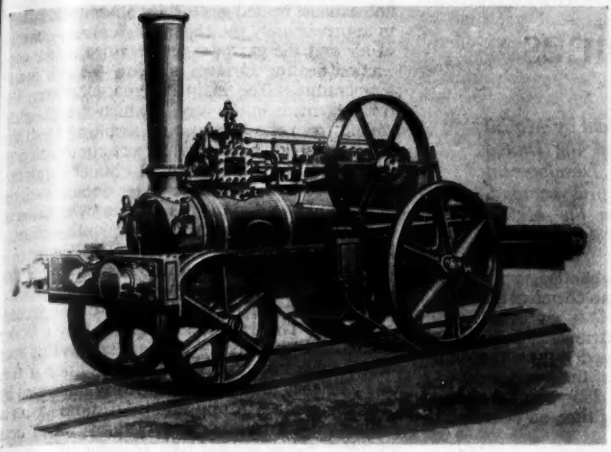
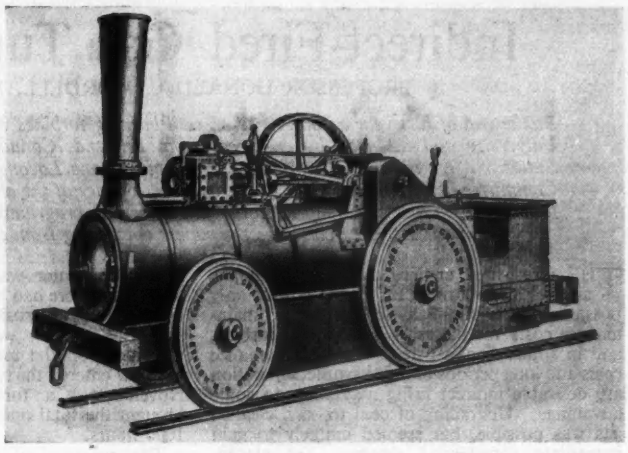


Fig. 28—Contractor's locomotive, with dynamo, built by Ransomes, Sims and Head in 1879



Figs. 26 and 27—(Left) Narrow-gauge Fowler locomotive, built, *circa* 1888, for the Bearpark Coal and Coke Company, near Durham. (Right) Compound locomotive "Lion," built and used by John Fowler and Co., as a yard shunter at the firm's Leeds works





Figs. 29 and 30—(Left) Locomotive built by John Fowler and Co. for military use. (Right) The "Improved Tramway Locomotive," of R. Hornsby and Sons

Fig. 21, also built for Messrs. Hall in 1867, and it will be noticed that the general design of the two are remarkably similar. This McLaren locomotive received some publicity in THE ENGINEER for January 18, 1924, and the dimensions given there were: compound cylinders, 6½in and 10¾in diameter by 12in stroke; driving wheels, 3ft 1in diameter; the single driving chain was adjusted by a jockey sprocket wheel.

Although the above two locomotives were the only ones built by Messrs. McLaren, it appears that the firm thought there might be a market for the latter type, and so offered a narrow-gauge design also. This would have been for a 2ft gauge with cylinders 4¼in and 7½in diameter by 8½in stroke; wheels, 2ft diameter; feed by pump and injector; speed, 15 m.p.h.

In 1899 Messrs. Marshall, Sons and Co., Ltd., Britannia Works, Gainsborough, built a single-cylinder geared locomotive of traction engine type with four large coupled wheels, but by whom it was ordered and why cannot now be traced in existing official records, except that it was intended for tramway use, although it should be borne in mind that the term tramway in the nineteenth century usually referred to mineral railways and not passenger-carrying street tramways. A considerable number of identical parts from the firm's 8 n.h.p. traction engine of the period were incorporated, the cylinder being 9in diameter by 12in stroke; pressure, 150 lb per square inch, diameter of wheels, 5ft 6in; flywheel, 4ft 8in diameter; drive by spur gearing and wheels coupled by side rods; wheel base, 6ft 6in; overall length, 21ft 11in; two water tanks holding 230 gallons; bunker capacity, 5½ cwt. This small locomotive is illustrated by two photographs on page 120 of *The Chronicles of Boulton's Siding*, and on page 56 of *The Locomotive* for 1925.

A number of Foden overtype steam wagons and a Ruston Proctor steam tractor are known to have been converted by their owners to work on flanged wheels, but for the purpose of the present review the subject matter has been confined to new construction only.

In conclusion the author wishes to thank those who have assisted in making this historical review as complete as possible, particularly Messrs. Ransomes, Sims and Jefferies, Ltd., Ipswich; Ruston and Hornsby, Ltd., Lincoln; and Aveling-Barford, Ltd., Grantham, all of whom have so willingly searched their archives for such data as now survives. Valuable assistance has also been given by R. Russell, Esq., of Quarry Bank, and D. H. Tew, M.A., of Oakham.

For the loan of photographs and drawings acknowledgment is due to the following: Fig. 1 is by courtesy of G. Alliez, Twickenham; Fig. 7, Controller of H.M. Stationery Office; Figs. 2, 13 and 19, F. Jones, London; Figs. 15 and 22, D. Stoyel, Orpington; Figs. 5, 9 and 14, A. W. Croughton, Sevenoaks; Figs. 6, 16 and 21, Locomotive Publishing Company, Ltd., London; Figs. 10, 11, 12, 22 and 28, editor of *Engineering*; Figs. 17 and 18, Aveling-Barford, Ltd., Grantham; Figs. 23 and 24, editor of the *Colliery Guardian*; Fig. 25, Dorset Ironfoundry Company, Ltd., Poole; Fig. 26, C. H. A. Townley, Hyde; Fig. 27, W. H. Whitworth, Manchester; Fig. 30, Ruston and Hornsby, Ltd., Lincoln; Figs. 8, 20 and 29 are from unknown sources and in spite of every effort being made it has not been possible to establish ownership of copyright, and for this omission the author begs indulgence.

For permission to reproduce the photographs in Figs. 13 and 14 the author wishes to thank Mr. J. F. Bruton, of Fulham.

Fig. 32—Locomotive built in 1896 for Glenlivet Distillery

Fig. 31—Compound locomotive built in 1915 by J. and H. McLaren for Hall and Co., Croydon

ROTARY AND INCLINABLE OPTICAL INDEXING TABLE.—A new rotary and inclinable optical indexing table, now being made by Optical Measuring Tools, Ltd., of Maidenhead, with either a 12in or 16in platen, has scales for both rotary and inclinable movements, which are read direct to 1 second of arc. In order to achieve this accuracy conventional eye-pieces with 60 minutes graticules have been replaced by units embodying optical micrometers of the wedge prism type. To facilitate reading at any position throughout the axis of inclination, a unit containing two eyepieces set at 90 deg. to each other is fitted for observation of the rotary scale. The tables incorporate rotary and inclinable motions controlled by worm drive to prevent slip when unlocked, and inside the inclinable base are locks to hold the work table rigidly and without distortion. Detachable datum blocks are supplied for the location of the table square with the axis of inclination.

Indirect-Fired Gas Turbines

By PROFESSOR DONALD L. MORDELL, M.A.*

At the end of last year a conference on coal burning turbines was held by McGill University and attended by engineers from England, Canada and the United States. After reviews of work in Europe and by the Locomotive Development Committee of Bituminous Coal Research, Inc., a paper of the above title was read, followed by others dealing with the experimental programme on the McGill turbine. Here we condense the papers emanating from the University.

THE direct-fired engine, though perhaps the simplest coal-burning turbine, is not the only possibility. Its simplicity brings higher maintenance costs for the ash separator and turbine, and in applications where minimal maintenance costs and long periods of uninterrupted operation are desirable indirect firing may show to some advantage. Upgrading of coal to, say, cleaned gas was possible, but seemed unlikely to gain immediate commercial success: the closed-cycle turbine was forced away from a pressurised furnace if coal was the fuel, and therefore became excessively large. The exhaust heated machine was less susceptible to small unavoidable fluctuations in coal feed rate, and it was not difficult to remove deposits from the unpressurised gas spaces. Such machines had been built by Stolze in 1872 and Jendrassik in 1938. C. A. Parsons, in England, has been running an exhaust-heated locomotive engine, while at McGill experimental work has been carried out for six years.

Review of Test Results

The construction of the experimental plant around the nucleus of a Rolls-Royce "Dart" and the first test programme were described in a paper to the Institution of Mechanical Engineers (THE ENGINEER, November 12, 1954, page 665). The engine proved itself practical and rugged, but the maximum power was 280 h.p. instead of the predicted 500 h.p., due to pressure losses, and the heat losses amounted to 40 per cent of the input. It was decided early in 1955 to modify the furnace and heater: the second heater (cold heat exchanger in Fig. 4 *loc. sit.*) was removed to gain a cycle more suited to locomotive working. A new design of cyclone furnace was put in hand in the hours the heater was dismantled, and it was found that there had been no chemical attack on, and only slight erosion of, tubes of a ferritic steel (the erosion was attributed to excessive velocities; on the redesigned engine the entire gas flow entered the tubes of the one heater). By November 4 a further 280 hours' running brought the total operating time on coal fuel to 1000 hours.

The redesign of the furnace was highly successful; slagging has been good and more than 75 per cent of the ash has been removed automatically, most of the rest settling as loose slag in the mixing section. The screw pump coal feed has been fairly successful, provided the moisture content of the coal does not vary too widely and all pieces of stray iron are extracted; much of the ash carry-over and deposition is believed to be due to irregularities in the feed. A blow-off of compressed air protects against overspeeding, and using this the set can be stopped in about a minute. The furnace and heater cool only slowly, and while they are hot a restart takes the order of one minute.

Appraisal of Furnace Problems†

The cyclone furnace was advocated by the Canadian Government Department of Mines because of its ability to burn a wide variety of low-grade coals, its suitability for highly pre-heated air and the convenience of ash disposal; the heat to cooling water was expected to be usefully employed in train heating. As the pressure drop in a normal cyclone would be too high, an enlarged and shortened throat was adopted (see Fig. 5 *loc. sit.*) in the belief that the carry-over would be cooled in the mixing section and pass through the heater. In fact, serious

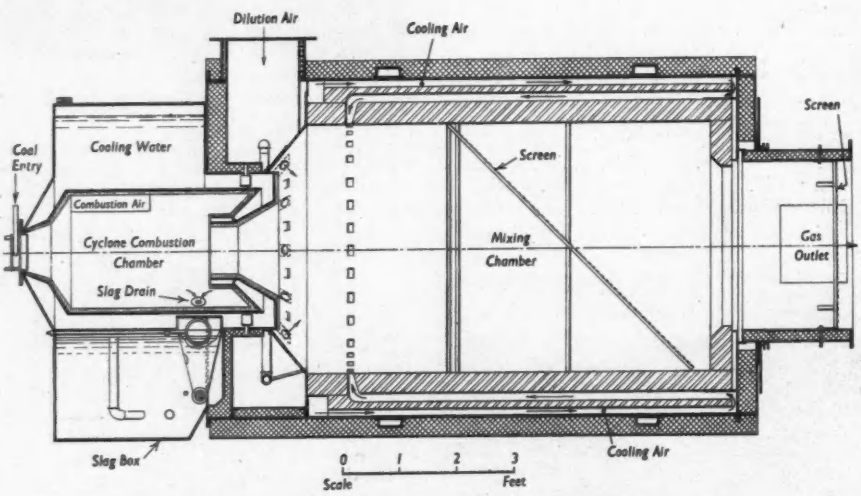


Fig. 1—Cyclone combustion chamber of exhaust heated coal burning gas turbine

expectation that heat losses would be reduced, slag removal facilitated, and carry-over reduced. The heater was rebuilt as a simple counterflow unit, using much of the original material; tubes of twelve different materials were included in order to get directly comparable information on corrosion resistance.

The rebuilt unit was ready for test on January 8, 1956, and during that year non-stop runs of 200 and 102 hours were made. Losses from the furnace were reduced to about 15 per cent, while there is still about 9 per cent lost from the heat exchanger tube plate cooling. After 485 plugging of the heater tube sheet and corrosion of the tubes resulted, and the redesigned furnace had a full re-entrant throat (Fig. 1).

There remain the problems of nearly 20 per cent loss of heat to cooling water and perhaps 14 per cent loss of power due to pressure drop through the furnace. Together with the high turn-down fuel consumption and the difficulty of control, these features lead to a study of other possible combustion systems for the exhaust heated cycle. The principal alternatives are pulverised fuel firing and grate combustion; the three systems are compared in Table I.

Review of the Requirements.—In both boilers and exhaust heated gas turbines the fuel is burned in approximately the chemically correct quantity of air and the gas inlet temperature to the convection heating surfaces is below the ash fusion temperature. The main difference between the two systems is in the way in which the gases are cooled from the temperature resulting from the approximately chemically correct combustion to the ash fusion temperature. In boiler firing this is achieved by radiation to water cooled surfaces of the boiler and in the gas turbine by dilution of the combustion gases by a large quantity of extra air.

In some applications of the gas turbine steam may be raised by utilisation of the waste heat for the production of additional power or for process purposes. This is best accomplished by a boiler located immediately before the stack, as this does not involve combustion of any additional fuel and efficiency (and power) is greatly improved by the additional heat utilisation. If more steam is required than can be generated by waste heat recovery alone, radiant heat transfer surface can be incorporated in the furnace, before the convection surface, and more fuel burned with correspondingly less dilution air. The total steam generation can be increased in this way to the point where no dilution air is employed.

Where dilution air tempering of the combustion gases before the convection surfaces is employed, as in all cases when the maximum steam generation is not required, the dilution air can be progressively introduced during the combustion process, thus restricting the maximum combustion temperature and reducing ash vaporisation. This technique of progressive dilution is not possible with cyclone combustion, which has the additional disadvantages of a higher pressure drop and some steam generation before the convection heat transfer surface whether it is required or not.

The use of a large excess air quantity as dilution air in the gas turbine allows very much higher heat release rates to be achieved in all suspension or gaseous phases of the combustion than for boiler furnaces. A normal rating for suspension burning of p.f. in boiler plants is 20,000 B.Th.U. per cubic foot per hour. In gas turbine p.f. combustion, rates of 200,000 or ten times are regarded as normal and some recent work at the Australian Department of Supply reports 1,300,000 B.Th.U. per cubic foot per hour when burning brown coal at an efficiency of 94 per cent. The ratings assumed for grate furnaces in this paper are about twice boiler practice as the increase in combustion rate will only apply to the gaseous combustion occurring over the grate. It is possible that rig tests of a grate furnace under gas turbine conditions would show a much greater reduction in volume to be possible.

Flexibility in the direct-fired gas turbine is assisted by the change of air density which occurs as gas turbine speed changes with change of load. This has the effect of maintaining velocities in the combustor substantially constant at all powers. Combustion in the exhaust heated cycle is at constant pressure so that air mass flow variation involves change in velocities as in boiler firing. Combustors such as the all-metal pulverised fuel combustors specifically developed for direct-fired gas turbine applications cannot be expected to operate at the same turn-down value when used on the exhaust heated cycle at constant combustor pressure. Pressure drop, velocities and turbulence will be reduced at low power condition, leading to less efficient mixing on all firing systems, poor combustion on pulverised fuel suspension burning and cyclone systems and poor ash separation in the cyclone: combustion in a fuel bed will best match these gas turbine characteristics.

A remedy may be sought in variable discharge orifices, which have to be applied to mixing or dilution ports as well as combustion air ports, so that the pressure drop and velocities may be maintained at lower speeds and mass flows. If this is done, however, the pressure drop in the combustion system will be a greater proportion of turbine expansion ratio at low powers and react unfavourably on the idling and low power characteristics of the gas turbine. It has to be appreciated, therefore, that the exhaust heated cycle may not be able to achieve as low idling conditions as the direct-fired machine when using pulverised suspension or cyclone firing.

* Director, Gas Dynamics Laboratory, McGill University, Montreal.

† Paper by R. W. Foster-Pegg.

Grate combustion, on the other hand, should not impose any limitation in this respect.

For locomotive operation the gas turbine has to compete with the diesel engine, which has the lowest idling fuel consumption of any prime mover. Unfortunately, the gas turbine has one of the highest. Turn-down on pulverised coal and cyclone combustion system will determine the idling consumption of a gas turbine, unless an oil burner or some other special technique is employed. The gas turbine itself will impose the limitation with a grate furnace. Depending on the gas turbine and firing system, the idling fuel consumption will be between 15 and 30 per cent of full load fuel consumption.

Probably of more importance than cost considerations is the effect of prolonged idling of a gas turbine on range or duration and the possibility of running out of coal if called upon to idle for an exceptionally long time.

For illustration, assume that it is normal to carry sufficient coal for eleven hours at full load to complete a ten-hour journey. The 10 per cent reserve of fuel is sufficient to permit forty hours' idling of the diesel (at 2·5 per cent of maximum fuel consumption) or 13⅓ hours' stand-by of a steam locomotive (at 7½ per cent), but only three hours' idling of the gas turbine (at 30 per cent). To permit the gas turbine to idle for the same length of time as the steam locomotive, the reserve of fuel must be increased to 40 per cent of the fuel required to make the journey non-stop at full load.

It will, therefore, be very necessary to make special arrangements so that the gas turbine can stand-by ready to pull trains at a few minutes' notice without this high idling fuel consumption. A condition is required similar to that of the steam locomotive, on which the engineer knows that if his fire is in good condition and there is sufficient steam pressure he can pull away at any time. With a combined gas-steam cycle and grate combustion stand-by conditions can be identical to the steam locomotive. The engineer adjusts the fire to keep the gas turbine components hot and ready for an immediate start and to maintain a steam pressure which is available to spin up the gas turbine to self-sustained conditions as soon as required. The steam is also available for train heat and to rotate slowly or " bar " the gas turbine during stand-by, thus supplying the air for combustion and preventing distortion of the rotating components by uneven heating. When the combined steam cycle is not used, power to bar the gas turbine and to start will have to be obtained from an auxiliary engine and the steam pressure gauge replaced by a temperature indication.

If a pulverised coal furnace is used, an oil burner would serve both to keep the engine hot and as a means of ignition of the coal on restarting. This would be more difficult with a cyclone because of the high heat loss to cyclone cooling water.

If the engine is kept hot in this way it can be quickly restarted and produce power in a period of time which will depend more on the response of the firing system than on the gas turbine. This has been demonstrated on the McGill gas turbine, as shown on Fig. 2. The fuel consumption under these conditions will be from 5 to 10 per cent of full load. With a grate type furnace, coal will be used, and a cost about equal to diesel idling cost can be achieved. With pulverised coal or cyclone systems in which oil will be required the cost will be from three to four times as much.

Conclusions for Stationary Plant.—The lesser importance of flexibility, the practicability of coal drying and grit separation from the stack gases, and the lower permissible maintenance, rule out stokers and grates for stationary use. The natural choice, therefore, falls on suspension burning of pulverised fuel for all stationary applications where tempering is by dilution air. When maximum steam generation is required and dilution tempering is not employed, the water cooling required by the cyclone s no longer a penalty and the advantage which a p.f. suspension burning system has over the cyclone, by its ability to introduce the dilution air progressively, no longer applies.

The total power produced by the maximum generation of steam and in the gas turbine is about ten times the power produced in the gas turbine alone, so that the power lost by the high-pressure drop in the cyclone is reduced from about 15 to 1 per cent of the power output. The power requirement of the pulveriser for p.f. firing is about ten times that required to crush the coal for the cyclone, so that in the case of maximum steam generation the costs in power of the two systems are about equal. Taking into account the very much greater convenience of ash disposal in the cyclone, adoption of this type of equipment where maximum steam generation is required can be foreseen.

Conclusions for Locomotives.—The cheapest, lightest and most simple combustion system for an exhaust heated coal-fired locomotive would be the suspension burning pulverised fuel system. It is absolutely essential with this system that when loaded into the locomotive the coal shall be free flowing and therefore dry. This suggests that an application could be found for this type of locomotive in industrialised areas where dense traffic would justify the special coaling facilities, but that in sparsely settled or under-developed areas it would not be economic. The large size of a dust collector for atmospheric operation suggests, on the other hand, that the dust loading of the stack gases will be high, which, unfortunately, is contrary to the idea of applications in densely populated areas.

The cyclone is not subject to the high stack dust loading of suspension burning, but the same limitation of dry coal applies. Also, poor turn-down and high power and cooling losses are against the cyclone.

Combustion in a fuel bed on a grate offers advantages which are very difficult to deny. Coal handled by normal techniques, proven by a hundred years of experience, can be used without difficulty. Turn-down can fully match the characteristics of the gas turbine, and standby operation is assured by the banked condition.

Stack loading with a spreader stoker would be high, but, because of the lower grate loading, less than in a steam locomotive ; however, for this reason a travelling grate or underfeed stoker would be preferable. The known difficulty of underfeed stokers with low ash fusion coals suggests that preheat could not be as high with this system as with the travelling grate. On the other hand, the travelling grate is more complex and requires up to 10 per cent moisture in the coal. The underfeed stoker is better with high caking coal, but gives more carry-over and lower combustion efficiency. The travelling grate provides continuous ash discharge. There is therefore little to choose between these two systems, but the better control of fuel bed conditions on the travelling grate suggests that this system lends itself better to improvements in rate of response and rapid pick up of load from the banked condition, and for this reason offers the best system for most of the railroad applications.

TABLE I—*Combustion Systems Performance and Features for a Self-Contained Coal Fired Exhaust Heated Gas Turbine*

			Suspension Pulverised Fuel		Cyclone combustor	Fuel bed and screened coal		
			With dust collector	Without dust collector	With mixing chamber	Spreader stoker	Travelling grate	Underfed stoker
Fuel		Type	Higher volatile, higher ash fusion		Higher volatile, lower ash fusion	Higher volatile	Fines and high S.I.[1] must be wet	Higher ash fusion temperature
		Treatment	Dry storage air transport metering pump pulveriser		Dry storage crushing to ¼in. metering pump air transport	Screened to 1in. × 0in. open storage mechanical transport		
Ash disposal based on 10 per cent ash coal		With hot gases	15 per cent of coal ash and carbon dust	7½ per cent of coal ash and carbon dust	3 per cent of coal ash and carbon dust and volatile ash	10·5 per cent of coal carbon and ash grit and dust	2 per cent or coal carbon and ash	5 per cent of coal carbon and ash
		Separately	None	50 per cent of ash + 50 per cent carbon	80 per cent of ash carbon free granular ash	65 per cent of ash + 30 per cent carbon	80 per cent of ash + 20 per cent carbon	70 per cent of ash + 30 per cent carbon
Thermo-dynamic performance	Heat losses, per cent of H.C.V.[2]	Combustion	7·5	7·5	1	6	1·5	3
		Cooling	0·0	0·0	17	8	8·0	8
		Total	7·5	7·5	18	14	9·5	11
	Power losses per cent[3]	Pressure	5·0	10·0	14	5·0	5·0	5·0
		Auxiliaries	2·5	2·5	1	0·7	0·7	0·5
		Total	7·5	12·5	15	5·7	5·7	5·5
	Thermal efficiency factor[4]		0·87	0·82	0·72	0·83	0·86	0·85
	Turn-down heat release, per cent of full load		30		30	10		
Control		Method	Coal pump speed		Simultaneous coal pump and air damper	Undergrate air flow followed by stoker or grate speed		
		Response	Very fast		Fast	Fast	Slow	Slow
		Stand - by operation	With separate burner (oil)		Separate burner (oil)	Banked coal fire, no separate burner		
Size		B.Th.U./hr./cubic foot Combustion	5·0	5·0	0·5	9		
		Mixing	2·5	2·5	5·0	5		
		Separation	—	5·0	—	—		
		Total	7·5	12·5	5·5	14		
		Useful[5] B.Th.U./hr./cubic foot	116,000	65,000	131,000	60,000		
		Additional space	Coal pump and mill	Pump, mill ash bin	Coal pump, crusher slag tank	Ash pit		

NOTE: [1] S.I. Swelling Index.
[2] H.C.V. Higher heating value of coal.
[3] Per cent of 50 h.p. per pound of air per second.
[4] Net thermal efficiency = gross thermal efficiency × factor.
[5] Absolute rate of heat release × thermal efficiency factor.

Appraisal of Heater Problems‡

When the original heat exchanger was designed the maximum gas inlet temperature was set at 1100 deg. Cent. (2010 deg. Fah.), while the air outlet (turbine inlet) temperature was 727 deg. Cent. (1340 deg. Fah.). The tube wall temperature near the inlet would depend on the individual film coefficients, but would be of the order 900 deg. Cent. (1652 deg. Fah.). It was at that time deemed advisable to have the gas inside the tubes, mainly due to cleaning considerations, but this meant that the tubes would be under a collapsing pressure of about 50 lb per square inch and a temperature approaching 900 deg. Cent. at the inlet. The choice of tube material was influenced by the extreme scarcity of stainless steels at that time, due to a steel strike in the United States. When it became possible to obtain Nimonic 75 tubes from England without

‡ Paper by J. Stachiewicz.

undue delays, these tubes were ordered. While it was realised that Nimonic alloy may be subject to sulphur attack, it was also known that this attack becomes serious only in reducing atmospheres. Since the products of combustion leaving the furnace contained some 70 per cent of the original oxygen content of air, it was felt that an oxidising atmosphere should prevail in the exchanger and thus minimise the corrosion problem.

In order to reduce the very high tube temperatures in the gas inlet region it was decided to have the air and gas streams flow in parallel in that section of the exchanger. Thus the design of exchanger shown in Fig. 2 *loc cit* was adopted. At about 4ft from the " hot end " the air stream was directed into a central duct from which it emerged at the tube sheet. The outlet nozzle was moved back along the shell to produce a parallel flow section. It was, of course, realised that this would increase the pressure drop considerably, but it was considered worthwhile at the time.

The very high inlet temperatures produced another problem, and that was the necessity for an accurate determination of tube plate temperature gradients. Within the first few diameters of tube length the gas film coefficient is much higher than that of the fully developed flow and will increase the already severe gradient even more. A mathematical solution for this particular thermal field was obtained, and the results showed the existence of considerable temperature gradients in addition to the high average temperatures within the tube plate. The feasibility of using ceramic (or even metallic) inserts was studied and the results were so encouraging that the exchanger was fitted with them right from the start. These inserts have been found excellent not only from the point of view of tube plate temperature reduction, but also as slag collectors and tube plate protectors.

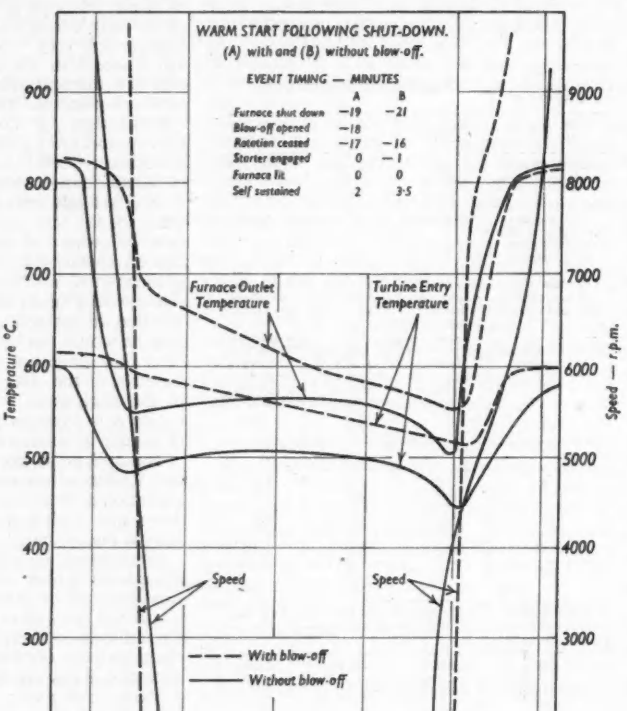


Fig. 2—Transient conditions on rapid stops and starts

In order to eliminate a superposition of pressure and thermal stresses a double tube plate construction was used and provisions for circulating a cooling fluid between the plates were made. This proved very satisfactory and we have used water cooling in all the tests. The only disadvantage, of course, is that this causes a heat loss of about 5 per cent, which, in the present cycle, is not recoverable.

One of the main advantages of this cycle is that it can use any type of coal and thus offer considerable economies of operation. Different coals have different ash fusion temperatures, however, and since it is impossible to eliminate completely the ash carry-over, some ash will inevitably reach the exchanger. If by that time the ash is below its fusion temperature it will travel right through the exchanger and reach the exhaust duct. If it is still in the fused state, however, it is sticky and adheres strongly to metal surfaces. It is these deposits of ash on the tubes which prevent the oxygen from reaching the metal surface, thus creating a reducing atmosphere underneath the deposit and causing rapid corrosion. On all the corroded Nimonic tubes which were replaced there was no evidence of corrosion except in places where heavy deposits of slag were present.

It is obvious then that in order to minimise this problem the temperature at the exchanger inlet should be kept below the ash fusion temperature of the particular coal used. When a cyclone furnace is used the problem is complicated by the fact that all the slag which is not drained off, but leaves the primary combustion zone as fly ash in the air stream, is originally in the molten condition. The secondary air, which joins the gas stream at the primary zone outlet, cools the combustion products and the fly ash particles simultaneously : the mechanism of heat interchange is, however, vastly different in the two cases. The fact that the exhaust gases arrive at the heat exchanger outlet at a temperature considerably lower than the ash-fusion temperature does not necessarily mean that all the fly ash will have been cooled to the same degree. The amount of cooling of the ash particle will depend on its residence time in the mixing zone and in the exchanger inlet duct, and also its size. It is obvious that the larger particle will not cool as quickly as the smaller one and its core may remain molten when it reaches the exchanger, even though the gas temperature is below the ash fusion point. It is also possible, if the particle contains carbon, that the combustion reaction is not completed by the time the exchanger is reached, and further heat release occurs on the exchanger surface. One way to guard against this is by closely controlling the performance of the cyclone furnace and reducing the amount of carry-over to an absolute minimum. No matter how carefully designed the exchanger, its performance over the long term will closely depend on the quality of the combustion in the furnace and the characteristics of the flow between the furnace and the exchanger. Using a different type of furnace, that is, one which does not rely on formation of molten slag for its operation, should be seriously considered, for even though the dry ash carry-over may be higher, it will not be so detrimental to the performance of the exchanger.

It may be interesting to note here that even a very severe ash deposition on the tubes never produced any noticeable difference in the overall heat transfer coefficient. This, of course, is due to the fact that, the overall value of the coefficient being of the order of 10 B.Th.U./hr square foot, deg. Fah., the additional resistance introduced by the scale is so negligible that it has no effect on the thermal performance, particularly since the deposition occurs only near the tube inlet. This ash deposition, however, affects the performance of the plant, to the extent that it increases the pressure drop through the exchanger.

In the original cycle the total pressure drop was further increased by the fact that all the air and most of the gas had to pass through two exchangers in series. This, together with the bad effect of the flow reversal in the hot exchanger and the lowering of maximum cycle temperature, led to a considerable simplification of the cycle when the time came to retube the " hot " exchanger. The " cold " exchanger was removed completely and the " hot " exchanger altered to eliminate the parallel flow section. " Doughnut " type baffles used previously were redrilled to change them into orifice type, with $\frac{1}{8}$in diametral clearance between baffle hole and tube, and this further reduced the pressure drop. Even though the gas flow through the exchanger is now higher (no by-pass being present), the total gas side pressure drop has not increased, due to the absence of the " cold " exchanger. Also, the higher flow gives a slightly higher gas film heat transfer coefficient which is beneficial. On the air side, the pressure drop has been decreased considerably, more than compensating for the reduced temperatures.

When the exchanger was retubed after 235 hours of operation on coal, tubes of various materials were installed in order to check on their corrosion resistance and a maximum temperature limit of 950 deg. Cent. (1742 deg. Fah.) was imposed on the gas inlet temperature. Since then the tubes were checked after a further 480 hours and the rate of deterioration of the Nimonic 75 was found to have decreased considerably. It was still necessary, however, to replace some Nimonic and 18–8 (austenitic) tubes which had corroded and developed leaks. The most encouraging development was that none of the ferritic (type No. 446) tubes showed any signs of corrosion and none have had to be replaced so far. The short tube life appeared to be a major obstacle to the development of a practical machine, but it is felt that there is now a solution to this problem, and that with a vengeance, since the ferritic tubes are much cheaper than their 18–8 and Nimonic counterparts.

Practically all of the pressure drop increase is due to the fact that most of the ash is deposited on the ceramic inserts protecting the tube plate, and forms a layer of slag which progressively reduces the flow area at the tube inlets. This is particularly serious, of course, if combustion is poor and the carry-over high, and in one early test it led to the complete blocking-off of about one-third of the exchanger tubes and substantial blocking of at least another third. Even this was not enough to stop the plant, although on top of the increased pressure losses the effective heat transfer area was reduced by more than 30 per cent. Testing experience shows that with reasonable combustion in the furnace the gas side pressure drop in the exchanger increases by about 15 per cent of its original value in a 250-hour test if no cleaning whatever is done.

Since the gas side pressure drop constitutes a considerable portion of the total drop in the cycle (about 36 per cent) an increase of 15 per cent is bound to affect the performance of the plant, although there is no decrease in the thermal ratio of the exchanger.

This points the way to the next logical step in the development of the plant, and that is the substitution of an air-tube heater for the present gas-tube exchanger. Thermodynamically, this will offer several advantages.

First, the larger pressure drop which the tube side fluid undergoes will now be associated with the clean air stream and hence it can be expected to remain constant throughout the test.

Secondly, the hot gas stream entering the shell side will penetrate the bundle without the practically direct impinging action which causes such a heavy slag build up and reduction of tube-inlet flow area in the present set-up. While deposition may still occur on tubes in the region of the inlet nozzle it will not cause such a large pressure drop as at present. Even if the gas side pressure drop does increase by 15 per cent during a 250-hour run, this will have a much smaller effect on overall plant performance, because the gas side loss will constitute a relatively small percentage of the overall loss.

Thirdly, the possibility of blocking off whole sections of the exchanger, eliminating much of the heat transfer surface, will be avoided.

The improved flow pattern will also help in preventing the local formation of reducing conditions, which should help the corrosion problem considerably. In the present tests the tubes which had their inlets blocked off by slag deposits were the first to fail by corrosion.

From the point of view of tube temperatures, the new design will also be superior in as much as the tube side flow area will be considerably smaller than the shell side area and since the mass flows are the same on both sides, the heat transfer coefficient on the air side will be higher than on the gas side. This will result in the tube wall temperature approaching more closely the air stream temperature, with a reduction of over 200 deg. Fah. on the present temperature levels.

The fact that the coefficient on the tube side will be approximately three times as high as on the shell side introduces the possibility of using externally finned tubes in the new heater. If the area ratio of the finned tubes is chosen properly considerable savings can be effected in the size of the exchanger. One type of finned tubing which appears to be well suited to this application is the "Lo-fin" tube manufactured by Wolverine, in the United States, and by Unifin Tube Company of Canada. If this tube can be made from ferritic steel, and there is no apparent reason why this should not be feasible (although it has not been done so far), the finned-tube design may be quite economical.

There are two possible objections to finned tubes :

(1) The ash deposit on the tubes in the gas inlet region may fill in the grooves between the fins (which are only $\frac{1}{16}$in high) and thus destroy the advantage of the higher surface area in that region.

(2) The fin tip temperatures will, of course, be higher than the tube wall temperature and in the hottest region this may cause excessive scaling and deterioration of the fins.

Both these objections can be met successfully by finning only part of the tube and leaving the hottest part bare.

Whether finned or bare tubes are used the air tube design offers even more mechanical advantages than thermal. The most important one is that the shell will be under essentially atmospheric pressure and, hence, much cheaper than in the present design. The hot tube plate temperatures will be considerably lower since there will be no hot gas impingement nor direct radiation. This will enable us to discard the complicated double plate water-cooled construction. It will also eliminate the considerable heat loss to the cooling water which we have to accept at present. All in all it appears that by switching the fluid streams considerable advantages can be realised, both with respect to costs of the exchanger and its thermodynamic performance.

Applications of the Exhaust-Heated Turbine

In the exhaust-heated machine, if the performance of the rotary components be specified, the major variable is the gas temperature at entry to the heater ; the higher the temperature, the lower the efficiency and the capital cost of the set.

For electric generation, a simple machine, resembling the present plant, could be built that would require no cooling water, but efficiencies over 20 per cent would be extremely expensive, and such a machine would only be used where coal was cheap or utilisation low. But the efficiency/cost relationship becomes far more favourable if two stages of compression and intercooling are introduced. Once water is available, waste heat recovery is possible, and efficiency is easily augmented ; the exhaust-heated turbine lends itself well to combined steam and gas cycles.

Locomotive Applications.—For locomotive applications there are certain operational demands not encountered in the stationary unit. Flexibility of operation becomes extremely important, idling and stand-by are frequently required and regular skilled servicing may be difficult to provide. The exhaust-heated cycle offers particular advantages in these respects as compared with a direct-fired machine.

Because a locomotive spends much time operating at reduced powers, its part-load efficiency is of great importance. Consider two locomotive designs which will be elaborated on later, referred to as the "simple" and the "sophisticated" types. The tables below give the power and efficiency relation for them :

(*a*) Simple :

Relative power, per cent	Actual power, b.h.p.	Thermal efficiency, per cent
100	1600	15
75	1200	15·6
50	800	14·6
25	400	13

(*b*) "*Sophisticated*":

Relative power, per cent	Actual power, b.h.p.	Thermal efficiency, per cent
100	2850	18·5
75	2100	19·0
50	1400	18·2
25	700	14·7

It will be noted that reasonable thermal efficiences are obtained over a wide power range. Comparable figures for a direct-fired machine are :—

Relative power, per cent	Thermal efficiency, per cent
100	18
50	14
25	9·3

Thus the use of the air heater, in addition to avoiding the problem of reconciling ash to turbine blades, gives high thermal efficiencies at the operating conditions which are experienced for more than half of the operating time of most locomotives.

It appears to be a firm law of Nature that a locomotive engineer requires his machine to be in a state of constant readiness at all times. In the days of steam locomotives this meant a banked fire and pressure on the gauge. With diesels it means that the engine is practically never stopped, but is idled for long periods. Because of the fact that the diesel idles at something like 2 to 3 per cent of full load fuel flow, this is not too serious cost-wise, although it does represent a wastage. With a direct-fired coal turbine, however, the idling fuel consumption may be as much as 30 per cent of the full-load fuel flow. With indirect firing, and a grate type of furnace, the fire can be banked so that the heater can be kept warm and ready for action. Tests show that with a hot furnace and heater full load can be reached from rest in periods of the order of one minute, so that one can envisage a virtual stopping of the rotating machinery whenever the locomotive is going to stand for more than ten or fifteen minutes. Under these circumstances the fuel consumption will be 5 to 10 per cent of full load. Assuming the higher value, there is a saving of 20 per cent of the full-load fuel flow for all the time spent idling. For a typical 2500 b.h.p. locomotive, idling 1000 hours per year, which appears to be a minimum figure based on actual operating results, the fuel saving on idling alone is of the order of 250 tons per year.

Finally it is a very desirable quality in a locomotive that inevitable troubles and defects cause a gradual deterioration in performance rather than a complete loss of power. The exhaust heated machine behaves in exactly this fashion, and tests have repeatedly shown that the attention required at relatively infrequent intervals consists of cleaning screens, or tubes, or breaking up ash deposits. None of this is skilled work and most of it can be done while the plant is running.

It is for reasons such as these that it is believed that the exhaust heated machine is particularly suitable for locomotive application. The only disadvantage is the size and cost of the heater. Its size is going to limit the power of a single unit to something of the order of 3000 b.h.p., although a practical demonstration of the suitability of extended surface heaters might raise this to nearer 4000 b.h.p. As far as the cost is concerned, studies show that, with a ferritic heater, the excess of heater cost over ash separators and coal pulverisers and pumps should be more than amortised by the savings in coal consumption at part loads and idling, and by the reduction, in fact the almost complete elimination, of turbine maintenance costs when the turbine operates on pure air.

(*a*) "*Simple*" *Machine.*—In many parts of the world there is a demand for a coal-burning locomotive capable of operation without water and capable of high utilisations. Because of low coal prices high thermal efficiency is not essential. Such requirements can be found in India, Pakistan, Australia, and South Africa. For such purposes the simple exhaust heated machine is ideally suited.

The machine investigated produces 1600 h.p. at a thermal efficiency of 15 per cent. It would be about 50ft long, weighing about 350,000 lb, and would carry enough coal for about twelve hours' average operation. If preferred, a shorter, lighter unit drawing a separate tender could be used. Electric transmission is employed, without excluding the ultimate possibility of direct mechanical transmission. The cost looks as though it is in the region of 250,000 dollars, depending upon the quantity produced and the number of extras.

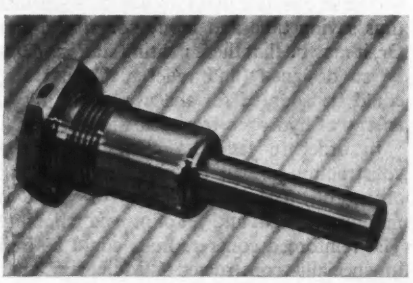
Although this machine will be very useful in many parts of the world, it cannot compete generally in North America with the diesel engine, at the present ratio of coal to oil prices.

(*b*) "*Sophisticated*" *Machine.*—This is derived from the simple machine by fitting a waste heat boiler to produce steam. This steam, if not required for heating a passenger train, can be injected into the gas turbine to increase the power and thermal efficiency. The nominal power is 2400 and the thermal efficiency 17·3 per cent, while it produces 4000 lb per hour of steam available for train heating. If not required, this boosts the turbine power to 2850 b.h.p. and the thermal efficiency to 18·5 per cent. The length over the frame is 63ft 5in, fully laden weight 450,000 lb. It carries coal for ten hours and water for three.

Its cost is about 350,000 to 375,000 dollars and it includes provision for 3000 b.h.p. of dynamic braking. A very detailed study has been made of its application to the Canadian railroad operating conditions. In main line service the overall annual savings in all direct operating costs varied between a low of 20,000 dollars and a high of 50,000 dollars, depending upon region, type of service and load factor. As the extra cost compared with the diesel engine is of the order of 100,000 dollars, it is clear that there is a large margin with which to amortise the extra capital cost and show a good overall saving.

Turbine Relighting

The susceptibility of the reverse-flow Bristol "Proteus" to extinction due to the intermittent ingestion of "dry ice" gave rise to the need for a "pilot light" in the combustion chambers to relight the engines immediately (see "Gas Turbines in 1956," page 26, January 4, 1957). For this purpose the K.L.G. glow plug illustrated was developed ; it consists simply of a tube, insulated from the end fitting, which projects into the flame and becomes incandescent. Plugs are fitted to alternate chambers, four in all, and if a sudden drop in compressor delivery pressure extinguishes the flame the plug initiates combustion immediately normal conditions return.



K.L.G. glow plug for "Proteus" engine : the active element is a tube of platinum-rhodium alloy

Platinum alloys of the Baker "S.R." series are used for the active elements. These grain-growth inhibited alloys are characterised by exceptional resistance to deformation and grain growth at temperatures approaching the solidus, as well as by the resistance to high-temperature corrosion expected of a platinum group metal alloy. Metallurgically similar alloys of the Baker "S.W." series have formed the standard aero-engine sparking plug electrode for many years.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents.)

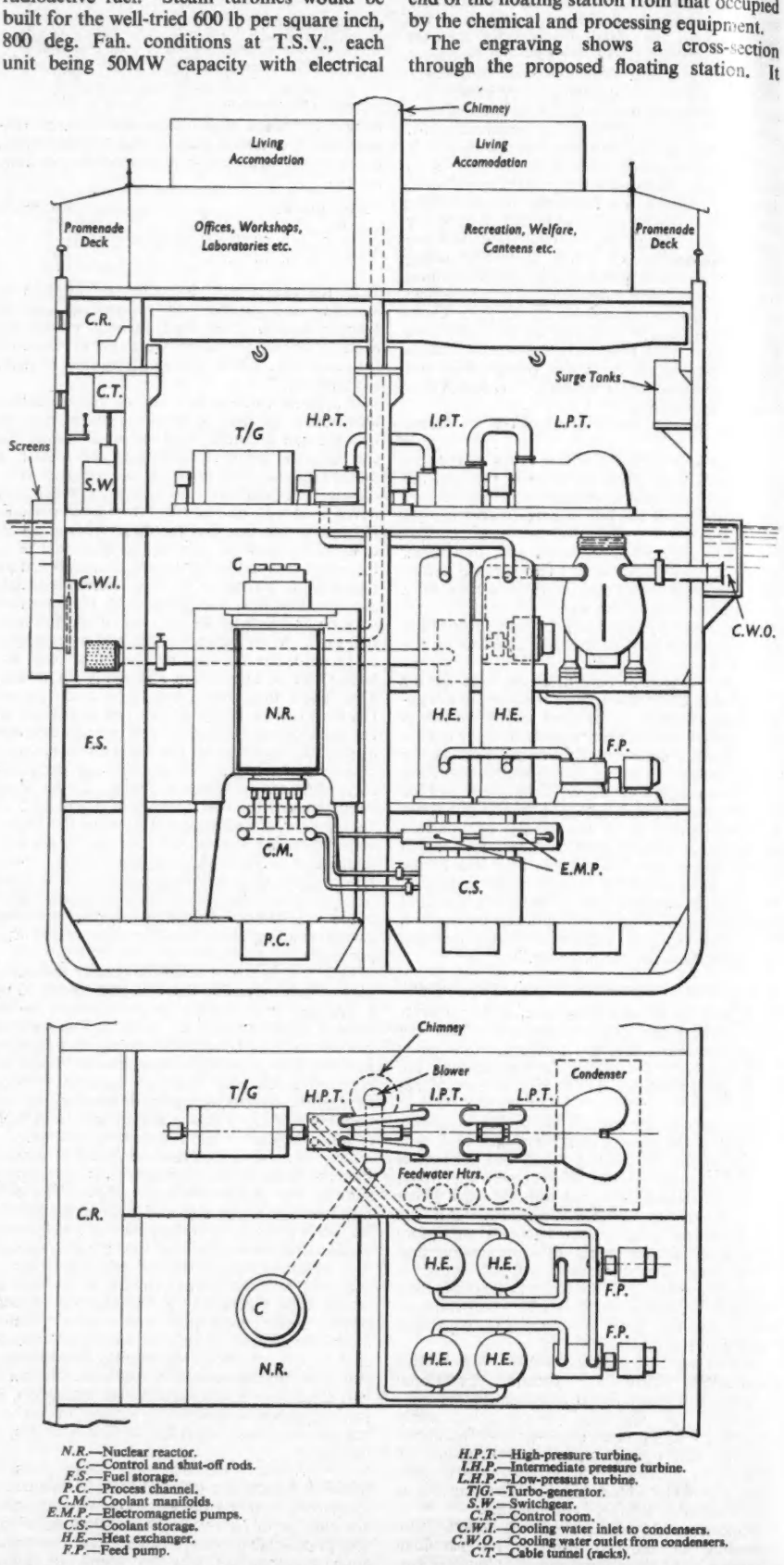
FLOATING STATIONS FOR NUCLEAR POWER PLANTS

SIR,—Already there is some evidence of difficulty in siting land stations, both for generation of electricity from coal and from nuclear energy. Sites near coalfields where cooling water is also available are being chosen for the larger new power stations of the Central Electricity Authority, and sites near estuaries will still be required for oil-fired plant which must fill the "gap" in our fuel resources for a few years. It is recognised that this "gap" must be made a minimum for national economic reasons, and a very large acceleration in the construction of "nuclear" power stations will undoubtedly be necessary. So far it has been traditional to acquire extensive sites on land to build our power stations, because of the large storage area needed for coal (or oil). For "nuclear" power stations the sites are near the sea to obtain cooling water and to discharge radioactive waste. However, with an accelerated programme of construction for "nuclear" power stations, the availability of sites will become most difficult; and the question may be asked why not have these nuclear plants on floating pontoons, or accommodated in large reinforced concrete floating hulls? These floating stations could be self-contained and will have all the cooling water they will ever need; the effluent waste could easily be discharged if these stations are located some distance from the coast. The only connection to the mainland would be a submarine cable to a suitable e.h.t. substation linked with the "grid."

The floating nuclear power station scheme should be considered as an interim measure until large land-based nuclear plant will become available by a gradual process of replacement of coal-fired plant. One may then ask what would become of the floating nuclear plants? The answer may well be that by the year A.D. 2000 (or sooner) they will be so obsolete that they could be scuttled, thus saving time and money on demolition. Or, it may be that these floating stations could be so designed (and redesigned) that they could be adapted for the use of the fusion energy of hydrogen from sea water.

In order to facilitate maximum rate of construction it will be necessary to standardise on a suitable design of plant of minimum weight and yet of proved reliability. The reinforced concrete hulls could be built in specially constructed "Mulberry" harbours, so that all the plant items are lifted by cranes and installed, as it were, on site. When complete, the floating nuclear station would be either towed to its mooring location and anchored or, alternatively, it could be self-propelled. The design of the plant items must be such that thermal efficiency is of less importance than reliability. The reactors could be of enriched U238, using NaK coolant, or they may be of the automatic boiling control type, but a complete automation system of monitoring this plant will have to be developed in order to utilise the nuclear fuel at a high rate of irradiation and to deal with continuous processing of radioactive fuel. Steam turbines would be built for the well-tried 600 lb per square inch, 800 deg. Fah. conditions at T.S.V., each unit being 50MW capacity with electrical generation at 11kV, stepping up to 132kV in a transformer substation at the opposite end of the floating station from that occupied by the chemical and processing equipment.

The engraving shows a cross-section through the proposed floating station. It



N.R.—Nuclear reactor.
C.—Control and shut-off rods.
F.S.—Fuel storage.
P.C.—Process channel.
C.M.—Coolant manifolds.
E.M.P.—Electromagnetic pumps.
C.S.—Coolant storage.
H.E.—Heat exchanger.
F.P.—Feed pump.
H.P.T.—High-pressure turbine.
I.H.P.—Intermediate pressure turbine.
L.H.P.—Low-pressure turbine.
T/G.—Turbo-generator.
S.W.—Switchgear.
C.R.—Control room.
C.W.I.—Cooling water inlet to condensers.
C.W.O.—Cooling water outlet from condensers.
C.T.—Cable tunnel (racks).

Cross section and part plan of floating power station showing approximate layout of reactor and 50MW turbo-generator set

will be seen that the reactor is of small dimensions and that there is adequate thermal and biological shielding. The turbo-generators are mounted on a heavy steel girder framework and are under two travelling cranes. From the partial plan view of one unit, it will be seen that the heat exchangers are arranged for the NaK connections at their lower ends and steam connections at the top adjacent to the turbine.

One obvious difficulty with the suggested scheme for floating stations will be a human problem concerning the "manning" of the floating station, which should be planned as an automation plant. Engineers and maintenance men will be necessary, and some form of rota duty as is used on our lightships may be possible. But, if long-term residential manpower is necessary, then sufficient scope for recreation, sport and welfare must be planned. When these floating stations have served their purpose we shall be a long way on the road to solving our power problems, possibly on quite new principles of nuclear conversion.

F. H. E. MYERS,
M.I.E.E., A.M.I.Mech.E.

Selsdon,
Surrey,
January 15, 1957.

"DAMTHEISM"

SIR,—I have probably reached an age at which I find many newly coined words and expressions distinctly displeasing to the ear! "Damtheism," whether it describes a "serviceable religion" or not, must be added to my aversions. But the point made under that title in to-day's issue is an important one. Those who design and construct dams and many other engineering works all too frequently remain unhonoured and unsung; all too frequently are they vilified as despoilers of the landscape. There is still a need, I submit, for far more emphasis to be given to an exposition of the benefits which mankind generally derives from the works of engineers. In your columns you ably describe the construction and operation of all sorts of engineering works and productions. Even in a technical newspaper it would not be amiss at regular intervals to proclaim that all these things make a substantial contribution to the wellbeing of the world.

W. JAMES

Harlow, Essex,
February 1, 1957.

Literature

Cams: Design, Dynamics and Accuracy. By HAROLD A. ROTHBART. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 76s.

THIS book is primarily intended for the designer and presents an extensive study on a subject in which most mechanical engineers have an interest. The book is clearly written and well produced. The diagrams, which are so important to the subject, are very numerous and well drawn. Students and teachers will find the book very informative. Mathematical treatment has been kept to a minimum, only that significant to design considerations being given. At the same time, because of the expanding field of high-speed machinery, the necessity for mathematical study in considering the effects of vibration, flexibility and backlash in cam follower systems is fully recognised and the relevant mathematical data are clearly given.

An introductory chapter deals with the various kinds of cam and follower and classifies them in terms of cam shape and follower motion. Follower characteristic curves of displacement, velocity and acceleration for a number of mathematically based cam forms are constructed graphically and analysed mathematically. The shapes of the acceleration curves, which are critical in medium and high-speed cam applications, are compared for all the basic cam forms. In a later chapter some of the more typical modifications to the basic curves used in high-speed machines and for special follower motions are fully investigated. Factors relating to the determination of cam size and cam profile are discussed, taking into account cam curvature, conditions giving loss of roller contact and pressure angle between cam and follower. Two methods of establishing the cam contour for various types of followers are given, first by layout procedure and then more precisely by calculation. Various kinds of cam with sliding or pure rolling action are described and the use of these in computing mechanisms is briefly described.

In a chapter under the heading of "Polydyne Cams" (by which the author denotes cam contours based on algebraic polynomials) a complete analysis is made of dynamic conditions in an automobile valve gear linkage. The method used recognises that faulty operation between cam command and response of the end member of the follower linkage, i.e. the valve, is due to elasticity of the linkages and sets out to eliminate "jump," limit vibration at running speed and by calculation to give control of the follower mechanism. In further consideration of the high-speed cam system attention is given to noise, wear, shock and vibration reduction. Conventional cam design generally assumes complete rigidity of cam and linkages without regard to vibration and deflection. Elasticity and mass of the follower system and the various sources which give rise to vibration are also discussed. Three methods are indicated for the establishment of vibratory response in the follower linkage; they are described in turn. First, an analytical method in which it is assumed that there is no vibratory effect from any previous cycle and only the cam period between dwells being covered. Secondly, a numerical method using the cam acceleration curve given graphically or numerically. It gives only the transitory response. Thirdly, by harmonic analysis of the actual motion of the follower, in which the steady state response due to forced vibrations only is considered. Each of these methods deals with a particular aspect of the dynamics of cam mechanisms, and for their application a knowledge of the theory of vibration would be useful in reading this chapter.

Much interesting and practical comment is made on the choice of mating materials and on deformation and stress existing between two elastic bodies in contact under load. The effects of manufacturing errors on cam profiles, surface irregularities and surface finish are also discussed. The final chapter describes a number of special cams and their application to various kinds of machine tools and industrial processing machines.

Throughout the text many worked-out examples serve to amplify the theory. A list of references is given at the end of each chapter, mainly taken from American literature.

The Design of Belt Conveyors. Mavor and Coulson, Ltd., Farme Cross, Rutherglen, Glasgow. Price £2 2s.

THE information in this handbook is based upon the extensive experience of a firm which has long specialised in the design and manufacture of belt conveyors. The book includes a number of alignment charts, whereby all the principal calculations normally involved in the design of a belt conveyor can be quickly and easily made without use of the usual formulæ and tables. The first chapter covers the choice of belt width and speed to carry the required tonnage; its alignment chart gives the peak loading in relation to material density, belt width and speed, whilst providing for the maximum lump size and maximum speed for the material. The next section deals with gradients for conveyors and is followed by a chapter on power requirements. In this chapter there are included elliptical charts on which the horsepower required to drive a conveyor can be read off with respect to any conveyor length, width, tonnage per hour and gradient. Subsequent sections deal concisely and clearly with the choice of belting; the spacing of idlers; vertical curves; belt take-up; belt loading chutes, feeders and hoppers; belt unloading trippers, ploughs and plotting the trajectory of materials; and tables on the density of materials, &c. To assist the user a number of worked examples are given at the end of the book for level, uphill and downhill conveyors. The text matter is supplemented by a large number of diagrams and illustrations and is well indexed.

Books of Reference

F.B.I. Register of British Manufacturers, 1957. Kelly's Directories, Ltd., and Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price £2 2s.—The twenty-ninth edition of this register, which is the authorised directory of the Federation of British Industries, lists the products and services of over 7000 member firms under more than 5400 alphabetical headings. Glossaries are included in French, German and Spanish, giving translations of every product term used in the main buyers' guide. Other useful sections include "Trade Associations," "Brands and Trade Names," and "Trade Marks."

B.B.C. Handbook, 1957. British Broadcasting Corporation, Broadcasting House, London, W.1.—This handbook is a reference book for all matters connected with the B.B.C., including its constitution, charter, and historical background. Sections are devoted to policy, income and expenditure, domestic and external services, departments concerned with programme supply, administration, and engineering, relations with the public, internal relations and finance. The book reviews recent achievements in broadcasting and provides an interesting guide to the workings of the Corporation.

Scientific Research in British Universities, 1955–56. Department of Scientific and Industrial Research. H.M. Stationery Office. Price 21s.—The British Council has collected together the names of the permanent research workers at British universities and university colleges, with a broad description of the main activities of each group or individual. Universities appear alphabetically, that of London being divided into colleges, medical schools, and the British Postgraduate Medical Federation. Indices of names and subjects, by college and department, are included.

Books Received

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Scotland's First Nuclear Power Station

No. I

In our issue of December 21, 1956, we announced the award of contracts for the first three British nuclear power stations designed to generate electricity on a commercial basis. One of these stations is to be built by the G.E.C.–Simon-Carves Atomic Energy Group for the South of Scotland Electricity Board: the proposed site, at Hunterston, on the Ayrshire coast, is at present the subject of a public inquiry. Some details of the design and construction of the station have been received from The General Electric Company Ltd., and are reproduced here.

THE nuclear power station which is to be built by the G.E.C.–Simon-Carves Atomic Energy Group for the South of Scotland Electricity Board is designed to have an electrical output of 320MW. An impression of the layout can be gained from the photograph of a model reproduced in Fig. 1. The main plant will consist of two gas-cooled graphite-moderated natural uranium reactors, each associated with eight heat exchangers, in which steam will be raised at two pressures to drive a total of six 60MW turbo-generator sets. Between the two reactors there will be a cartridge cooling pond.

The Reactor

Core.—The reactor core consists of accurately machined graphite bricks and tiles built into the form of a cylinder (actually a twenty-eight-sided plan section), 50ft 6in in diameter and 28ft high, weighing nearly 2000 tons. The central portion of this structure is the core proper, containing the fuel and control rod channels; the remainder constitutes a graphite reflector, which reduces neutron leakage from the core. The reflector has an average thickness of 3ft at the sides and 2ft 6in at the top and bottom. There are 3288 vertical fuel channels built into the core and arranged in the form of a square lattice with a pitch of 8¼in. These channels are subdivided into groups, in the centre of each of which is a further channel for a control rod.

To increase the total heat output of the reactor without overheating the central channels, the neutron flux distribution (which directly governs the local heat output) is flattened so that as many channels as possible run at the maximum heat rating. This flattening is done by inserting neutron-absorbing stainless steel rods into a number of the central core channels; the flattening rods provide an artificial wastage of neutrons equal to the geometrical leakage in the outer portion of the core. As the fuel is burned up during operation the absorbing material is gradually removed and the final flattening is done by using depleted uranium in the centre of the core. A higher burn-up of the central fuel elements is thereby attained. The maximum neutron flux in this region is approximately $2{\cdot}0\times10^{13}$ neutrons per square centimetre per second. In the outer region of the core the moderator channel is reduced in diameter by increasing the thickness of the graphite tubes containing the fuel elements, as described below. By reducing the channel diameter the mass flow of coolant gas up the channel is decreased; accordingly the temperature of the fuel can and, therefore, of the outlet gas, is kept up. The outlet gas temperature from these outer channels, where the level of reactivity, and hence the fuel temperature, is lower than in the centre of the core, can thus be kept up at least to the level of the gas coming from the central core channels.

Control of gas temperature is achieved by "gagging." Steel plates with central holes of varying diameter are mounted at the bottom of certain fuel channels outside the flattened region. The flow of gas up these channels can therefore be restricted, depending on the degree of gagging, and gas outlets can be maintained at approximately constant temperatures.

Fuel Elements.—The reactor fuel consists of pure natural uranium metal containing 0·7 per cent of fissile U-235. Each fuel element is a cylindrical rod 1·15in in diameter and 24in long, weighing nearly 17 lb., encased in cans of magnesium alloy with fins. Ten such fuel elements constitute the complete charge for one vertical channel. The system of supporting these elements is designed to facilitate charging and discharging without subjecting the lower to undue stresses because of the weight of uranium. To this end each canned fuel element is individually supported and located by non-metallic "spiders" inside a relatively large-bore graphite tube. The assembled fuel elements, each consisting of a fuel cartridge and a graphite sleeve, can be mounted one on the other within the fuel channel. Location of the tubes centrally in the main moderator channels is effected by small graphite lugs on the tubes and by a "cup and cone" arrangement of successive tubes. The main gas flow is up the bore of the graphite tube in direct contact with the fuel elements. In addition, a small quantity of gas is allowed to pass up the annular space between the graphite sleeve and the main moderator channel to extract the heat (about 6 per cent of the total) generated by collision processes in the graphite itself.

Other advantages claimed for the "replaceable channel fuel element" are: first, that the smooth external shape of the graphite cylinder should result in reduced abrasion of the main channel during charge and discharge operations; secondiy, that if reactions between the carbon dioxide coolant and graphite lead to the formation and eventual mass transfer of free carbon, the affected graphite can readily be removed and replaced; thirdly, in the event of a bad fuel cartridge burst, it is likely that the contamination would be discharged with the faulty element and the moderator channel could continue to be used.

Pressure Vessel.—The reactor core rests on support plates on a steel grid which is, in turn, supported on a steel skirt. The grid consists of a large number of steel boiler plates about 7ft in depth, arranged in "egg-box" fashion with a thick steel top plate, with sufficient space between each section to accommodate thirty-six channels of the reactor. On top of the grid structure rests a further series of thick steel plate providing an accurately levelled surface for the erection of the core structure.

Around the core (Fig. 2) itself is a cylindrical inner shell, with a domed top and open at its lower end. This shell is made of relatively thin boiler plate.

A spherical pressure vessel 70ft in diameter completely encloses the core grid and inner shell. This spherical vessel will be welded on site from steel plates 3in thick.

Carbon dioxide at 150 lb per square inch gauge will be blown into the outer spherical vessel via eight 5ft diameter ducts situated at "equator" level. The cool gas then passes downwards between the outer and inner vessels, and upwards through the support grid and the core channels.

Inner Shell.—The inner vessel is made of a silicon-killed mild-steel boiler plate and has to withstand only the pressure drop across the core of 4 lb per square inch. It is cooled by the incoming gas stream and at its hottest point it is designed to be at a temperature approximately 130 deg. Fah. below the gas outlet temperature of 745 deg. Fah.

Outer Spherical Shell.—It was decided to build a double-shell pressure vessel because of the diffi-

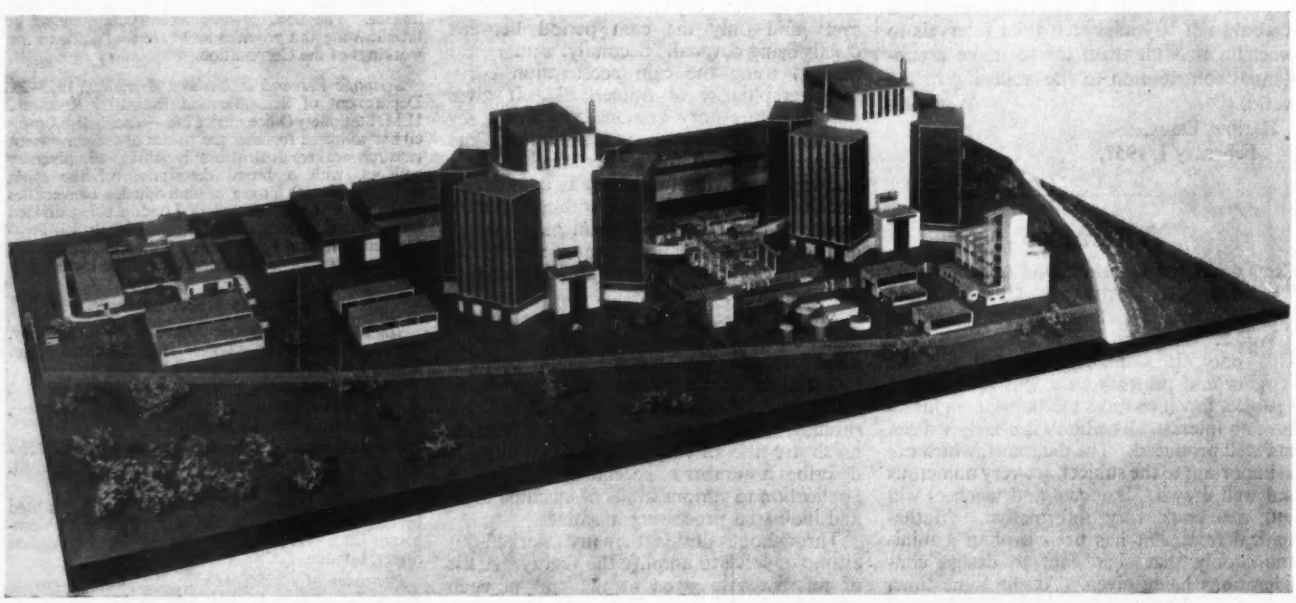


Fig. 1—Model of G.E.C.-Simon-Carves nuclear power station to be built for South of Scotland Electricity Board. The cartridge cooling pond is between the two reactors

culty of finding one material combining the three required properties : (*a*) resistance to deformation by creep at the operating temperature ; (*b*) resistance to failure by brittle fracture, and (*c*) weldability. The thick, outer, pressure-resistant, spherical vessel will be made of "Coltuf 28" (a product of Colvilles, Ltd.), which meets the requirements (*b*) and (*c*) and the relatively thin inner shell will be of creep-resistant, silicon-killed, boiler plate.

The sphere will thus withstand the gas pressure of 150 lb per square inch gauge without being subjected to the maximum gas outlet temperature of 745 deg. Fah. In fact, under normal running conditions no part of the sphere will be at more than 450 deg. Fah., which is well below the creep range of the material.

Segments of the sphere, with gas inlet and outlet nozzles welded in, will be partially prefabricated at the works of the Motherwell Bridge and Engineering Co., Ltd., and the final welding in the reactor building, with the help of television monitor screens.

The 3288 fuel channels, in "charge groups" of thirty-six channels each, are continued downwards through the grid by "fixed channel tubes." In any one charge group, the fixed channel tubes are bent inwards into gentle curves so that their open lower ends can be fed from a point below the centre of the group. Vertically below each centre line is a standpipe for its charge group, and through each of these 101 standpipes any one of thirty-six fuel channels in a charge group can be reached by the charge machine. The standpipes project upwards through the spherical shell and downwards to a point just below the biological shield forming the roof of the circular charging chamber. The lower ends of the standpipes are sealed with a steel door protected by a concrete shielding plug.

The charge machine vessel is roughly cylindrical, 30ft high, and designed to withstand the full gas operating pressure. It is seated in a carriage mounted on four wheels which run on tracks mounted on a central turntable. The turntable runs on two concentric sets of tracks. By rotation of the turntable and movement of the carriage along it, the nozzle in the top of the charge machine can be aligned directly beneath any chosen standpipe.

The first operation of the charge machine is to move off the turntable into the loading bay in the main reactor building. Above this bay is the charge preparation room where the components of the replaceable channel fuel element are assembled under clean conditions. Five fuel elements, together with a support device and empty graphite tube are lowered into one tube of a "magazine tube pair" which consists simply of a long open-ended cylinder of polished stainless steel. The empty graphite tube ensures that the lowest fuel element is in the moderator section of the core and not in the surrounding reflector area below. Five more elements are then lowered into another similar tube, the two being strapped together and forming a "magazine tube pair" containing a complete fuel element charge for one channel. The pair of tubes is then guided downwards through a hatch in the charge preparation room floor into the opening in the top of the charge machine. This process can be repeated if necessary until several pairs of tubes are supported in racks within the machine. The magazine itself is shielded by a 1ft thickness of lead. The loaded machine is driven back on to the turntable and the nozzle positioned below the required standpipe.

Precise alignment to within $^1/_{10}$in is done with two television cameras mounted at right angles on top of the charge machine. The cameras are focused on vertical datum lines on the standpipe and the charge machine nozzle, and the position of the machine is adjusted until these lines coincide on the television monitors in the control room. Clearance between the top of the charge machine nozzle and the bottom of the standpipes is about 3in, which is taken up by raising the whole machine on four synchronised electrically operated jacks until the surfaces abut. The flanges on the two nozzles are then clamped together over an "O" ring by eight CO_2-operated piston clamps situated radially round the nozzle.

The charge machine is now in position ready for any required operation. Under normal reactor running conditions the sequence of operations would be the removal of one column of ten fuel elements from a fuel channel, followed by the charging of ten fresh elements into the channel. Both these operations would be carried out with the reactor on load and under pressure, the gas supply to the channel being maintained by a positive-displacement channel-cooling compressor contained within the charge machine pressure vessel. Discharged radioactive fuel elements are retained within the machine during the recharging process and are later removed for separation of the graphite sleeves from the fuel cartridges, the latter being stored in the cooling pond.

Two other duties expected of the charge machine are axial inversion and group charge and discharge.

Axial Inversion.—The process of axial inversion consists of removing the partially irradiated fuel elements contained in a channel, and reinserting them in a different order, whereby those elements which have been highly irradiated in the centre of the core become positioned at the ends, and vice versa, e.g. fuel elements removed in the order 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 would be recharged in the order 6, 7, 8, 9, 10, 1, 2, 3, 4, 5. Fuel elements in any one channel thus receive a much more uniform total irradiation and the burn-up of the fuel is considerably increased.

Group Charge and Discharge.—This process enables several channels out of a total number of thirty-six in any one charge group to be charged at one setting of the charge machine. It is the method which would be adopted if it were desired to charge the fuel elements in batches, e.g. after a change in fuel element design. Such an operation would, of course, be done under reactor shut-down conditions, whereas the other two processes described above would be undertaken with the reactor on full load and under full gas pressure.

Charge Machine Testing and Maintenance.—It is intended that once a day the charge machine should be run into a test bay to undergo a series of tests simulating the handling of fuel in the reactor, to prove that the many and varied motions of the machine are in proper working order. The test bay is provided with a dummy standpipe end and above it a group of thirty-six dummy fixed channel tubes at a level corresponding to that inside the reactor. The fourth bay surrounding the charge machine chamber is an exit bay through which the machine can be conveyed to the charge machine maintenance building. Three identical machines will be provided for the station so that one can be undergoing planned maintenance while the other two are in operation beneath the reactors.

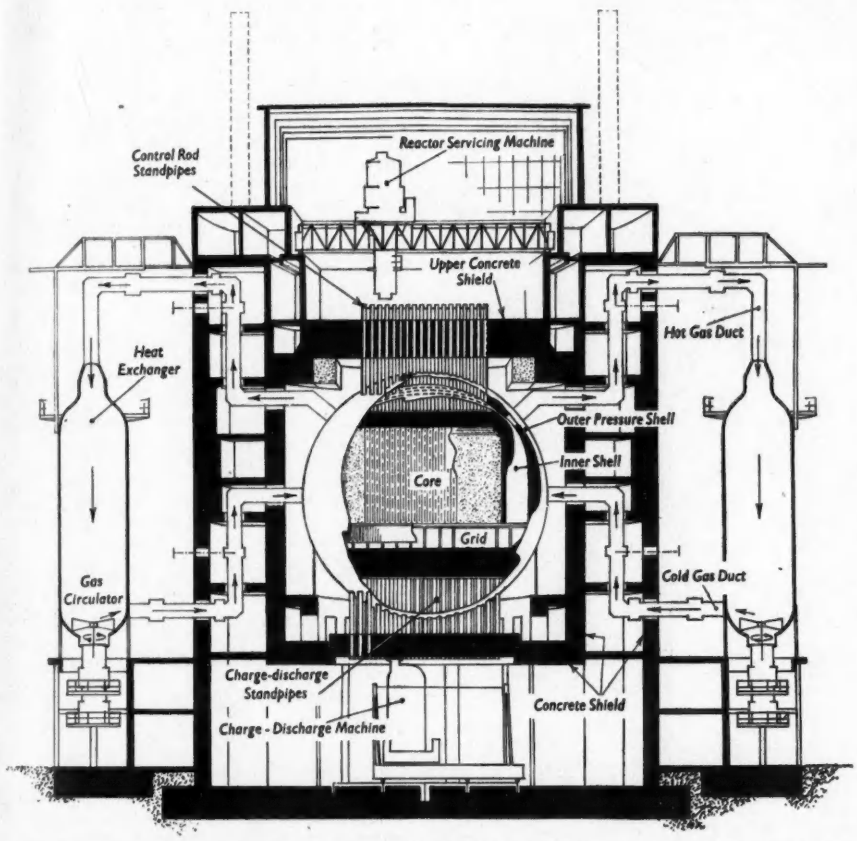


Fig. 2—Sectional diagram of one of the reactors showing the gas circuits and the machines for reactor servicing and for fuel element charge and discharge

processes will take place on site. All main seam welds will be X-rayed at 50 per cent completion and again at 100 per cent completion ; the assembled vessel will be stress-relieved by hot gases from an oil-fired heating system.

Shielding Structure.—A concrete biological shield will surround the reactor. At the base of the reactor the shield will be 6ft thick, increasing to a total thickness of 9ft at the sides, while the roof shield will be 10ft 6in thick. The 9ft side shield will be split into two parts on two arcs between the core and the heat exchangers, yielding "blimps" in which the gas coolant ducts will be contained. The inner walls of the blimps will be 4ft thick and the outer ones 5ft thick. The shielding will also be locally thickened opposite the cold ducts in the inner wall.

Charge and Discharge Operations

All the fuel charge and discharge operations for each reactor will be done by a single multi-purpose machine working in a shielded chamber below the reactor, under pressure and while the reactor is on load. The movements of the machine will be remotely controlled from a room

The Cartridge Cooling Pond

The cartridge cooling pond is between the two reactors (Fig. 1) and is common to both. It is 186ft long by 53ft wide internally, and 18ft deep. At the end of each conveyor duct is a heavily shielded concrete block house, and between the two block houses on opposite sides

of the pond is a concrete wall dividing the pond into two unequal sections : the larger is for storing normal discharged cartridges and the smaller is for cartridges from channels in which a burst has occurred.

The boat carrying a cartridge down the chute is tilted at the end of its travel, tipping the cartridge into a hopper. The hopper, controlled from the separating room, can then be rocked to either side, causing the cartridge to roll down a chute leading either to the " clean " or " dirty " section of the pond, where it comes to rest under water visible to the pond operator.

The pond operator picks up the cartridge with a simple mechanical manipulator and places it in a storage skip. Inside the skip is a grid rack in which up to 192 cartridges can be stored vertically. When the skip has been filled it is picked up by the pond transporter crane and carried under water to a predetermined position in the pond, where it will remain for 120 days. During this period gamma activity decreases to a level at which a reasonable thickness of shielding, say, about 1ft of iron, can be used for the transport coffin. Without this cooling period a coffin made of iron about 20in thick would be required.

The capacity of the cooling pond is such that, besides the normal number of cartridges issuing from one running reactor, the complete fuel charge from one reactor can be dumped within it in the event of an emergency.

At the end of their storage period in the pond the skips are reclaimed by the pond transporter and placed in the transport coffins for removal from the site. The coffins are lowered into the pond by overhead gantries, one at each end of the pond. The coffin lids are removed under water by the pond transporter, the skip is lowered into the coffin and the lid is replaced. The loaded coffin is lifted out by the gantry, washed down, placed on the transport vehicle, and removed for reprocessing by the U.K.A.E.A.

Control Rods

In the reactor core structure there are 208 channels which can be used for control rods, each control rod channel being associated with sixteen fuel channels. In practice, not all of these core channels will contain control rods.

Access to the control rod channels is obtained from above the reactor through tubes passing upwards from just above the core, through the inner and outer shells, through the upper biological shield, terminating in a set of 208 larger diameter standpipes. Housed in each of the control rod standpipes is the individual control rod mechanism for that channel. The remaining standpipes give access to the fuel channels from above with the aid of the reactor servicing machine described below.

The control rod mechanism (Fig. 3) consists of a flexible stainless steel wire rope wound on a conically-shaped drum driven by a low-frequency permanent magnet motor. Each control rod is moved in or out of the core by applying a three-phase, low-frequency supply to the motor stator ; the rods are held out of the core by reducing the frequency of the supply to zero, i.e. a d.c. condition. The low-frequency supply is obtained from a motorised induction regulator uniquely connected with transformers and rectifiers. The control rod motors are arranged in groups of four, each group being coupled to the same low-frequency supply and these motors thus driven in synchronism. The low-frequency supply equipment is situated outside the biological shield. The stainless steel wire rope supporting the control rod passes through a small-bore hole in the centre of a long concrete shielding plug which is attached to the control rod mechanism. The control rods themselves consist of a specially developed lightweight boron-containing material canned in a thin stainless steel sheath. Short lengths assembled in this way are then placed within the main control rod tube. The completed control rod is 21ft long and 2in in diameter. The rods are divided into four groups—two coarse control groups, one fine control and one safety group. The two coarse groups are capable of a combined reactivity control of 4·85 per cent. The fine group controls 0·4 per cent reactivity and the safety group 1·25 per cent.

In an emergency all the control rod motor stators would be de-energised simultaneously by cutting off the power supply, and the four groups of rods would fall into the core under gravity. The rods initially accelerate until they are well into the core, but towards the end of their travel a braking force is applied so that their final velocity is low. This characteristic is governed by the conical shape of the winding drum and the impedance of the closed winding in the stator. During operation of the reactor the position of each control rod is detected by a synchro-transmission system coupled directly to the winding drum. Slack or overtaut rope detection is also incorporated.

The Reactor Servicing Machine

The reactor servicing machine is a travelling pressure vessel situated above the upper biological shield of the reactor. Its main purpose is to enable planned maintenance operations to be carried out on the control rods and control rod mechanisms while the reactor is under load

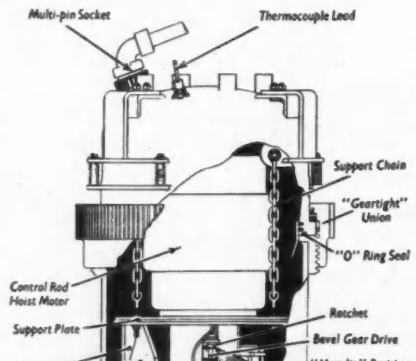


Fig. 3—Diagram showing general arrangement of control rod mechanism

and pressure. The servicing machine can be positioned over any one of the 208 upper standpipes by longitudinal and cross travel motions exactly as in a conventional travelling crane. From this one setting the servicing machine can also communicate with any of the sixteen fuel channels served by each standpipe.

All the machine's controls are mounted, together with the pressure vessel, on the crab of the machine. The operator sits at the control console and is provided with local shielding to protect him from the gamma activity arising when certain units are removed from the reactor. In addition, a limited amount of general concrete shielding is applied to the vessel of the machine. Use is again made of closed circuit television to supervise the various operations of the machine.

The bottom booms of the main travelling bridge of the machine are provided with trolley beams, on which a pair of 5-ton travelling electric hoists are mounted. They are used for handling the emergency shut-off valve and distance pipe connecting the standpipe to the servicing machine nozzle, and as general-purpose cranes covering the area of the reactor roof.

Various other duties fall to the reactor servicing machines in emergencies, as described below.

(1) Should a control rod cable break, the rod will fall freely and come to rest on the guide pan, whence it can be retrieved by the servicing machine and replaced.

(2) In the event of the fuel elements jamming in the channel and failing to be discharged in the normal way, a CO_2-operated ram unit can be brought into operation at the end of a rotatable telescopic tube. It will function in any of the sixteen fuel channels which can be reached from one control rod standpipe, and can deliver blows of varying intensity on the graphite sleeve of the top fuel element.

(3) Certain fuel elements will be fitted with thermocouples to provide data on the temperature distribution within the core. Such elements, with their thermocouple leads attached, cannot be loaded by the charge machine, and will therefore be inserted with the aid of the telescopic tube units in the reactor servicing machine.

(4) The thermocouple fuel elements have a special top cap with a built-in cutter device ; the cutter is operated by a CO_2-driven percussive hammer again mounted on the telescopic tube units of the servicing machine. When the thermocouple cable has been severed it is wound up and disposed of, while the fuel element is left free to be discharged in the normal way.

(5) When the reactor has been blown down to atmospheric pressure it is possible, by means of the reactor servicing machine to lower into the interior a special television camera unit. It enables the upper part of the inner shell and the channels of the graphite structure to be examined.

(6) In cases of extreme emergency a special grab attached to one of the telescopic tube units can be used to discharge fuel elements. Sufficient flexible stainless steel tubing is provided so that the grab can be lowered down through the core of the reactor, down the chute and charge tube of the charge machine and, if necessary, to the bottom of the magazine tubes some 135ft below. This operation would be performed only under shut-down conditions, and fuel elements removed singly would be placed in a special coffin to be lowered down a hoist well and conveyed to the cartridge cooling pond.

(7) The sixteen-way rotary selector valves of the burst slug detection system are dealt with on a planned maintenance basis in the same way as the control rod mechanisms. The valves are contained within the control rod standpipes and the entire mechanism can be changed by the servicing machine with the reactor under load and pressure.

Burst Slug Detection Equipment

Burst slug detection (B.S.D.) equipment is installed to detect the escape of radioactive fission products due to failure of a fuel element, and to locate the channel containing the faulty element so that the reactor and gas circuit may be safeguarded from the release of fission products. These functions are performed by successive sampling, in groups of four, of the gas from the 3288 fuel element channels throughout the reactor. Any solid components in the gas are filtered out and the daughter products of gaseous fission products are electrostatically precipitated to give a measure of the extent of a fault in an element. Each filter unit contains a Geiger counter to detect any deposits or uranium oxide. The precipitators are located in two diametrically opposite rooms on the reactor cap. When the sample test shows a high activity level in a group of four channels, it is possible to operate the B.S.D. equipment so that the individual faulty channel in the group may be located. Selection of channels is by means of two sets of rotating, graphite-lubricated valves mounted outside the reactor for ease of maintenance.

A permanent record of each sampling operation is automatically charted and a comprehensive system of alarms indicates to the control engineer in the central control room not only a burst slug but also any fault in the equipment itself. Automatic operation reduces to a minimum the time taken for a complete reactor scan,

and additional equipment provides for the frequent sampling of a suspected channel without lengthening unduly the time between samples of any other channel.

Steam Raising Plant

Eight heat exchangers are grouped in pairs around each reactor, to remove heat from the circulating gases, and raise steam for driving the turbo-generator sets.

The heat exchanger designed by Simon-Carves, Ltd., consists, in principle, of two water-tube boilers (high pressure and low pressure) in a vertical cylindrical pressure shell. The heat exchanger shell is of welded construction, 19ft 6in diameter internally and 73ft 6in high overall, and will be fabricated and erected by the Motherwell Bridge and Engineering Company, Ltd. It is self-supporting and stands on a cylindrical support and base ring. The complete shell, weighing 210 tons, will be lifted into position by a 300-ton Goliath crane.

Hot CO_2 flows downwards across banks of self-draining multi-loop tube elements which form the economiser, evaporator and superheater sections of the boiler. Individual tube elements are connected in parallel by headers situated in accessible positions outside the pressure shell. As at Calder Hall, this arrangement allows any leaks to be detected without entering the shell and also enables individual elements to be replaced without cutting and welding inside the shell. The elements are supported only at their ends to keep the supporting structure out of the gas stream, the individual tubes forming an element being tied together by welded straps to give the element rigidity. The parallel tubes are all of the same length and hence the tube banks occupy a square section within the circular area provided by the shell. The remaining segmental areas are used as a means of vertical access within the shell and are baffled at intervals to prevent by-passing of gas. All the headers are arranged on one side of the pressure shell and consequently a single structure is used for each pair of units ; the drums, headers, pipework, fittings, access platforms and stairways are contained in the space between the units, and each pair of units is enclosed in a weatherproof structure.

Extended Surface Tubing.—The inlet gas temperature to the heat exchangers will be about 750 deg. Fah. and the outlet temperature 400 deg. Fah. The temperature difference is thus relatively low and the area of heat exchange surface required is correspondingly large compared with fuel-fired plants of the same output. Great attention has, therefore, been paid to the problem of obtaining the most compact arrangement of surface to keep to a minimum the overall size of the plant, particularly the pressure shell.

The solution adopted is the use of close-pitched, small diameter mild steel tubes* with an extended surface in the form of fins. In all the evaporator and economiser banks the fin will be a mild steel spiral wound on to and continuously welded to the tube.

A different construction is used in the superheaters where the lower internal heat transfer coefficients do not justify such a high surface extension ratio. The superheater tubes will simply have two longitudinal strip fins welded on top and bottom.

Gas Circulation

Gas Ducting.—The quantity of gas circulated through each reactor and heat-exchanger system is over 5000 lb per second. The main ducts are 5ft in diameter and are made of boiler quality carbon steel plate. In each of the hot and cold duct systems there are three hinged joints to take up the expansion. The runs of ducting are thus divided into four separate sections connected by flexible bellows at the hinges.

The arrangement of each section on constant load supports allows the whole system to move freely under all conditions of temperature without transmitting reactions back to the pressure shells of the reactor and heat exchanger. The problem was simplified by keeping the axes of each duct system in one plane ; with ducting laid out in a third dimension it would have been necessary to employ gimballed joints instead of hinged bellows.

Rapid-closing isolating valves are included in the gas circuits at the reactor inlets and outlets ; a faulty circulator or any component of a circuit can be quickly isolated from the rest of the plant for maintenance purposes without shutting down the reactor. A reduced reactor load can then be carried by the units remaining in service. The whole of the duct system is of welded construction.

Important auxiliary items associated with the coolant circuits are by-pass filter circuits to keep down the level of dust formed by possible corrosion or erosion of the plant, by-pass drier circuits to remove any moisture introduced into the gas by possible slight leaks in the boiler tubes, and the carbon dioxide storage plant and pipework system for filling the plant at start-up and for making good any losses caused by leakage.

Gas Circulator.—One gas circulator is situated in the base of each heat exchanger, so that it handles the gas at the lowest temperature. Since the power consumption of the blower represents an appreciable fraction of the station output, it was necessary to aim for a design of the highest possible efficiency consistent with reliability and ease of operation. The pressure losses in the reactor, heat exchangers and gas ducting are high and the circulators have to develop a pressure rise of several pounds per square inch. Nevertheless, the pressure level in the system is high and the compression ratio is therefore low. These conditions require a design which is essentially a large single-stage fan designed to handle carbon dioxide at high pressure and a moderately high temperature. A centrifugal machine was chosen in preference to an axial-flow one, since more experience was available on the design of impellers of the size required.

The impeller, with backward curving vanes, is mounted on a vertical overhung shaft at the base of the heat exchanger. The pressure-shell of the heat exchanger is large enough to accommodate the impeller, the diffuser and an inlet fairing to the eye of the impeller, thus avoiding the need for a special pressure casing. The circulator unit—impeller, shaft, seal, bearings, drive and cooling system—is suspended from a flange on the pressure shell, care being taken in the mounting to prevent the transmission of vibration to the shell. If lengthy maintenance work is required on the motor and drive unit it can be lowered on to a specially designed road vehicle and transported to the station workshop ; a spare unit can then be fitted in its place. The shaft seal will either be of the rubbing face type or of the viscous oil type, and extensive full-scale running tests are being carried out on both these seals at design pressure and temperature.

To meet the conditions of starting-up and shutting down, of load changing and of bringing individual steam-raising units into operation, a variable speed drive was considered necessary. The drive is a tandem-armature, 2200 h.p., 1000 r.p.m. d.c. shunt motor supplied through transformers and twelve-phase steel tank mercury arc rectifiers having grid control by individual phase shifters. The phase shifters may be clutched together to give a ganged control of any number of circulators. Each motor is air cooled by an external fan, the air being exhausted over the commutators at the ends.

(To be continued)

* The use of non-ferrous metals such as copper for the heat exchanger tubes would improve the heat transfer characteristics considerably. But it is possible that small particles of copper might become detached from the tubes and deposited on the magnesium alloy fuel cans to form local areas of low-melting eutectic alloy leading to penetration of the can and release of active fission products. Copper being incompatible with magnesium in this application, development work on heat exchanger tubes was, therefore, confined to all-steel constructions.

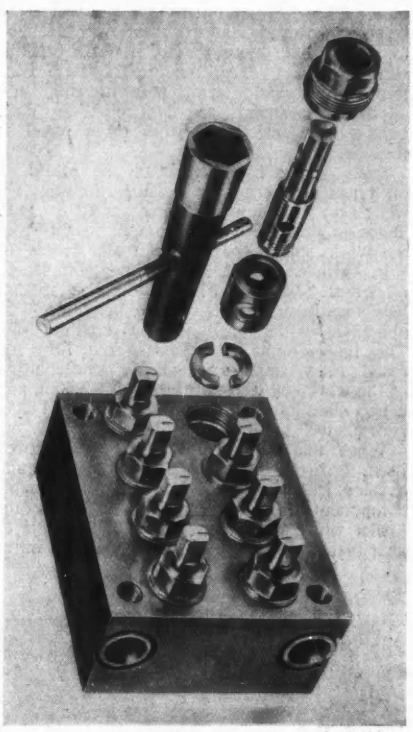
Gas Sampling Manifold at Calder Hall

Particulars have been received from Richard Klinger, Ltd., Sidcup, Kent, of a special cock manifold designed and made by the company for the United Kingdom Atomic Energy Authority and installed at the Calder Hall plant. These cocks, one of which is illustrated here, are of three-way construction and are ganged together to form an eight-unit cock manifold in two groups of four.

Each Calder Hall reactor is divided into eight separate areas, each of which is controlled by a fifty-four-point gas sampling plant. From each area, 212 sampling pipelines are led through the manifold cocks, which reduce the number of channels to fifty-three. The sampling pipes are welded into the manifold cock bodies which are mounted on the same framework as a fifty-four-way rotary selector valve. The selector valve is connected via a cooler and filter to a chamber in which is housed a precipitation unit and radiation detection gear. This equipment reveals the presence of any radioactive gases that may have leaked into the CO_2 in the system, and the source of the leak can then be traced by testing gas taken from each sampling cock separately.

In the manifold each cock is sealed by a renewable sleeve of compressed asbestos which is compressed around a parallel plug with a lapped finish. Stainless steel eyelets in the sleeve protect the packing from the action of the passing fluid and the position of the eyelets is fixed by a moulded ridge on the outside of the packing sleeve which fits into a corresponding groove in the manifold body.

The illustration shows a manifold with one of the cocks dismantled to show its parts. The split



Cock manifold for gas sampling plant at Calder Hall

ring fits into the groove at the bottom of the plug and locates it firmly in an axial direction when the compressed asbestos packing sleeve is forced against it by tightening the nut. The square ends of the plugs are unsymmetrical and the special operating key shown is provided to ensure that the ports in the cocks are positioned correctly. When the operating key is reversed it provides a box spanner which is used to tighten the nut compressing the packing sleeve. A special extracting tool is supplied for removing the plug from the body should the cock require repacking. The pipes are welded to the block and an annular recess is machined around each connection in the body to relieve welding stresses. To prevent the risk of any leakage, each group of four cocks is covered by a sealed bonnet which is only removed when the cocks are to be operated.

The maker states that the satisfactory working of these cocks was shown recently when one of the reactors at Calder Hall was closed down to trace a leak of carbon dioxide. In the course of the tests all the cocks on the reactor were found to be operating in a satisfactory manner.

Automatic Loading Device for Gear Hobbing Machines

A loading device which has been developed by Churchill Gear Machines, Ltd., has been successfully applied to the firm's "Rigidhobber" arranged for automatic cycle operation and to transfer lines of these machines hobbing cluster gears for the automobile industry. The new device is actuated by the hydraulic system of a machine and it closely reproduces the movements followed by an operator manually loading and unloading components on a machine.

SOME particularly interesting equipment has been designed and built by Churchill Gear Machines, Ltd., Scotswood Road, Newcastle upon Tyne, for the automatic loading and unloading of work on Cleveland-Churchill Mark IV "Rigidhobber," automatic cycle, gear hobbing machines, and in transfer equipment to serve lines of these machines. This development work was started some three years ago, when the firm sought a method of automatically loading gear hobbing machines to give higher production rates and to reduce operating costs. As a first step the "Rigidhobber" was redesigned and built with a fully automatic cycle in which the tailstock, hob slide, and workhead were arranged for sequential operation to perform various cutting cycles. These machines have a continuous automatic axial hob traverse, and all their movements are controlled by push buttons and selector switches on a panel at the side.

Each of the five models of the Mark IV machines now being made have capacities for work up to 8in diameter and 4 D.P. Three models have a maximum height from the work spindle to the tailstock centre of 37in, 43½in and 49½in, with a maximum length of travel of 8in. The two other models have maximum spindle-to-centre heights of 37in and 43½in, with a maximum travel length of 16in. They have a range of hob speeds from 70 to 500 r.p.m., the vertical feeds available per revolution of the work being from 0·006in to 0·250in, and a hob slide infeed rate from 0·040in to 1·80in per minute.

When this design of machine had proved itself, the firm then proceeded with the design and development of attachments which would enable components to be loaded automatically. A tube loader which could handle a selected range of gear blanks up to 2¾in diameter was first introduced and used with success. Investigations were then carried out with a view to developing a work-handling device which could reproduce as closely as possible the movements followed by a machine operator when manually loading and unloading work on a machine. Such a device would enable a far wider range of components to be handled automatically, and, at the same time, make possible a fully automatic transfer line for such things as cluster gears required in large numbers in the automobile industry.

As a result of this work the transfer arm fitted on the machines we illustrate was developed. It is operated by the hydraulic system incorporated in the machine, and its movements are controlled in sequence with the machine and transfer conveyor cycles. Jaws on the end of the arm are designed to grip a component, lift it from the conveyor, swing it into position above the work-holding fixture, lower the component and release it when it is held by the fixture. At the end of the machining cycle the work is gripped as it is released by the fixture and returned to the feed conveyor. On the conveyor indexing, another blank is picked up and the cycle recommences automatically. A point of interest is that the maker has designed one standard type of arm which can be used to handle almost all types of gears and shafts, it only being necessary to change or rearrange the grip jaws to accommodate different diameters.

A "Rigidhobber" fitted with a transfer device and conveyor for feeding blanks and removing cut gears is illustrated in Fig. 2. The particular

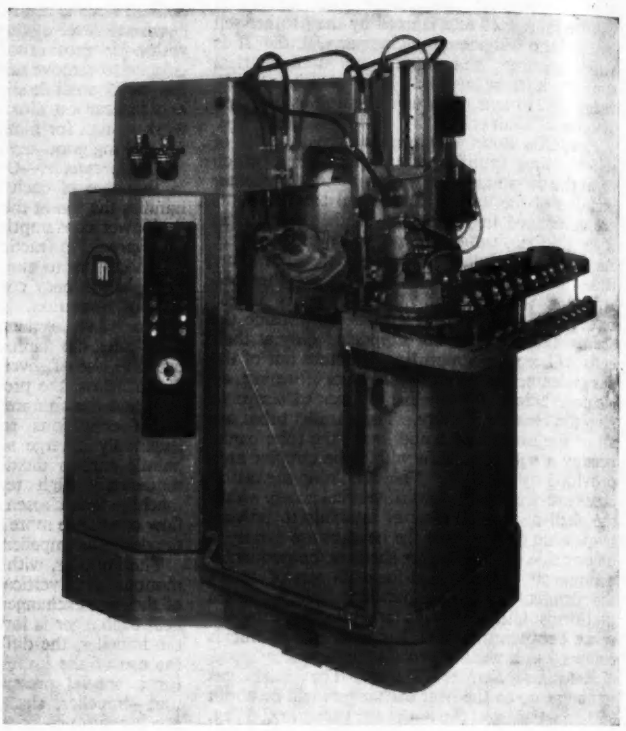


Fig. 2—Hobbing machine with automatic loading device and work conveyor

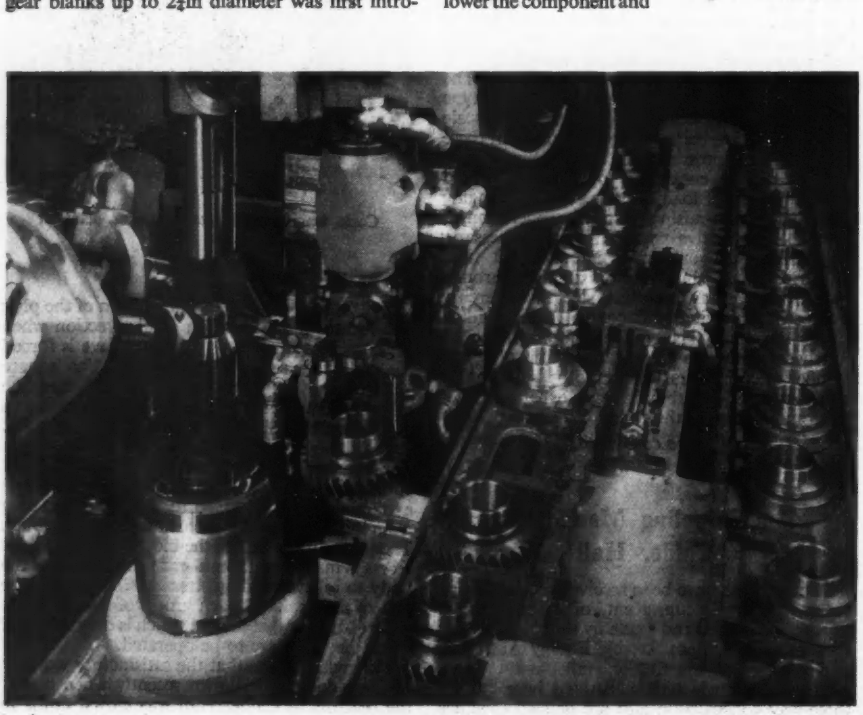
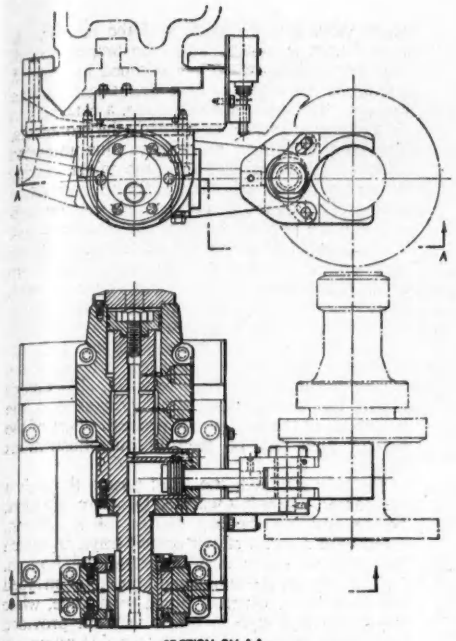


Fig. 1—Finished gear in the jaws as it is being returned to the conveyor. When the jaws have opened to release the gear the conveyor automatically indexes to bring a blank to the loading position

gear handled is the second speed main shaft gear for an automobile; it is made from a forged blank and is 3in outside diameter. With a hob speed of 260 r.p.m. and a vertical feed of 0·060in per revolution of the work the machine hobs thirty gears an hour. In this instance a lower feed rate than is normal is used owing to the call for a high quality finish in the root of the gear.

The design and operation of the arm can be seen in the accompanying illustration Fig. 1, and the drawing Fig. 3. The transfer device is supported from its main hydraulic cylinder assembly, which is fixed through a back plate to the lower end of the slideway of the tailstock column of the machine. The piston-rod of this hydraulic cylinder incorporates the transfer arm assembly, and at its lower end slides through a supporting and turning assembly. The sleeve in the pivoted jaws of the transfer arm are actuated by a hydraulic piston and are so arranged that as they are pushed forwards the jaws close on the work with a sweeping or gathering action. This action is designed to make a very high degree of accuracy unnecessary in locating parts on the work transfer conveyor. When the work is held, the main piston-rod raises the arm, and the turning movement to swing the arm between the conveyor and the machine fixture is effected by a vane motor in the lower support assembly, through a keyed sleeve in which the piston-rod slides.

In the sequence of transfer arm operations a micro switch is operated when the conveyor has come to rest with a blank in front of the open jaws of the transfer arm. Pressure fluid is then admitted to the arm cylinder and as the piston retracts the jaws close on the work blank. A sequence valve then comes into effect to admit



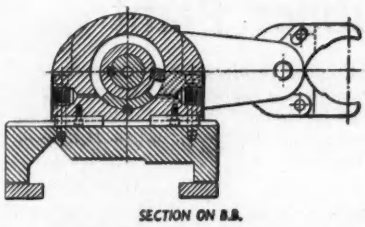


Fig. 3—Construction of work transfer device as used on line of three machines hobbing cluster gears

fluid to the main cylinder and raise the main piston with the blank held in the grips. As the arm is raised another sequence valve admits fluid to one side of the vane motor and the arm is swung round until the blank in the grip registers over the hobbing fixture.

At this point the flow of hydraulic fluid to the main cylinder is reversed to lower the piston and deposit the blank on the fixture and a sequence valve reverses the hydraulic pressure in the arm cylinder to open the grip. Simultaneously with downward movement of the transfer arm the automatic machining cycle commences with the tailstock moving down to clamp the blank. The speed of transfer arm movement is controlled by the setting of a needle valve.

At the end of a gear hobbing cycle retraction of the hob-head slide actuates a micro-switch, through which the grip is closed on the gear. The subsequent transfer arm cycle is a reversal of the loading cycle described above. At the end of this return transfer cycle, when the grip releases the gear on to the conveyor, one of its jaws contacts a micro-switch which brings the hydraulic cylinder used for indexing the conveyor into operation. One stroke of this piston moves the conveyor along to locate another blank in front of the grips, and a switch operated at the conclusion of this stroke restarts the grip closing and loading cycle of the machine.

The gears carried away from the loading station of the conveyor are swept to one end of the conveyor circuit, where they gravitate down a chute ready for removal. The conveyor fitted on this machine works on a closed circuit, and when it needs reloading the machine automatically stops at the end of a cycle when only two blanks remain to be cut. At the same time a warning light on top of the machine begins to flash. If the two remaining blanks are the last of a batch the machine operates on a non-repeating cycle and a button has to be depressed to start each sequence of hobbing operations.

In Fig. 4 there can be seen three "Rigidhobbers" arranged as a transfer line for hobbing three of the gears on a tractor layshaft cluster gear, the blank of which weighs some 18 lb. On the first machine—that at the far end in our illustration—forty-three 7 D.P. teeth with a 30 deg. helix and 20 deg. pressure angle are hobbed on the largest diameter. On the second machine thirty-six similar teeth are hobbed on the second diameter; and on the third machine seventeen 7/9 D.P. spur teeth are cut. In each case a 3½in diameter, two-start, hob is used, running at 250 r.p.m. The production of the line is controlled by the time taken for hobbing the forty-three tooth gear, and is set for twelve shafts an hour.

On the transfer conveyor of this line the shafts are moved by a series of latches mounted on and reciprocated by a chain which is drawn along the required indexing length by one stroke of a hydraulic cylinder at the outgoing end of the line, against the pull of a return spring at the opposite end of the line. Each of the machines is fitted with one of the new transfer arms, and as their hobbing cycle times vary, the arms of all three of the machines must be positioned above the conveyor and fully opened to release the three finished components before the indexing movement takes place. When all three sets of grips are open above the conveyor, an indexing switch is automatically tripped, and at the conclusion of the transfer movement, to position fresh components, the loading cycle for all three machines begins. A main control station enables the line of machines to be operated from a central position when required. A rotary switch on this panel can be set for automatic running, or to stop the machines at the end of a cycle or to run them individually. In the event of finished shafts not being removed from the outgoing end of the conveyor a trip switch is contacted, after a predetermined number have accumulated, and the whole line of machines stops automatically at the end of a cycle.

The firm has also built a transfer line of six machines for hobbing three sets of teeth on an automobile layshaft cluster gear at the rate of sixty shafts an hour. On this line the machines are arranged to work in pairs, each two machines simultaneously hobbing the same gear on two shafts. For this reason, the transfer line is arranged to index two stations at a time. The shafts in this case are located on spigots on a conveyor chain and not moved by latches. The conveyor is indexed by a similar cylinder to the three-machine line illustrated.

The maker points out that, with the new design of loading arm, in-line machines connected by a transfer conveyor can be arranged very close together, and if at any time individual batch working is required on one or all of the machines they can readily be fitted with a modified design of conveyor. Up to the present the transfer arm has only been used on hobbing machines, but its design lends itself to a far wider field of application on automatic cycle machines working individually or in-line. In the course of a recent visit to the works of Churchill Gear Machines, Ltd., we were able to see the three applications of the transfer arm described above in operation. In each case their smooth, positive operation was particularly noticeable, as was the fact that only a minimum amount of time was lost in loading and unloading the gears and cluster shafts.

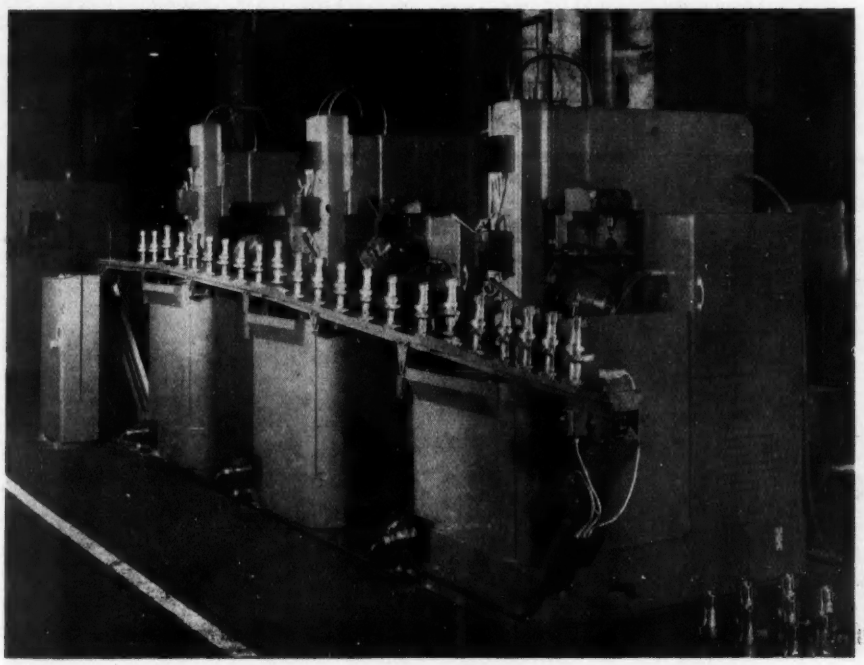


Fig. 4—Transfer line of three "Rigidhobbers" arranged on a layshaft cluster gear

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FACTORY EQUIPMENT EXHIBITION.—The 1957 Factory Equipment Exhibition is to be held at Earls Court, London, from April 29 to May 4 next, and will occupy 250,000 square feet. At the exhibition there will be displayed the products and services of some 300 manufacturers. The British Productivity Council, the Incorporated Plant Engineers and the Institute of Materials Handling are organising conferences to be held at the time of the exhibition.

OIL TANKER "SPYROS NIARCHOS."—A new film in Eastman colour, entitled "Super Tanker," which has been produced by the film unit of Vickers, Ltd., was shown recently in London. The film records some of the engineering work involved in the building of what is claimed to be the largest tanker completed to date. The "Spyros Niarchos," which was fully described in our issue of June 15, 1956, carries a deadweight of 47,750 tons. Sequences covering the launching ceremony, the trials and the fitting-out of the tanker, were included. The film is available in 16mm and 35mm sizes.

EXTINGUISHER FOR METAL FIRES.—A special-purpose fire extinguisher is now being made by The Pyrene Company, Ltd., 9, Grosvenor Gardens, London, S.W.1, to meet the problems associated with fire outbreaks involving metals such as sodium and calcium, or magnesium and aluminium, in the form of powder or swarf. The new extinguisher is charged with 25 lb of dry chemical powder which is discharged under pressure provided by a cartridge of CO_2 gas. The dry chemical powder is applied to the burning metal by means of an applicator comprising a long, tubular metal extension terminating in a cone-shaped spreader. The applicator ensures that the discharge of dry chemical powder is delivered lightly on to the fire in order to prevent the danger of scattering which is associated with this class of fire. A "squeeze-grip" control valve enables the flow of dry chemical powder to be shut off at will.

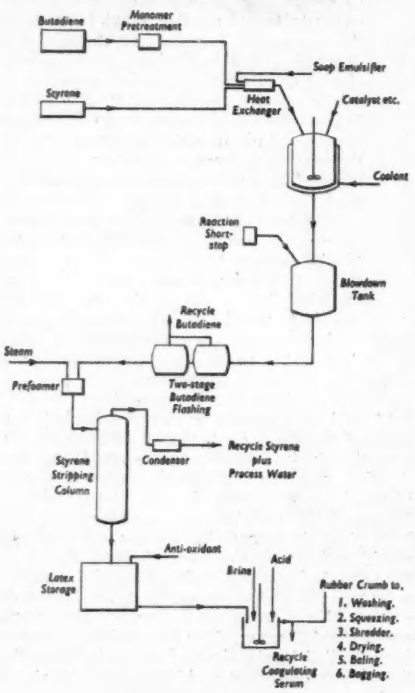
Synthetic Rubber Plant

The building of oil refineries and associated chemical plants in this country has made available adequate supplies of the monomers butadiene and styrene. The availability of these raw materials has enabled the Dunlop Rubber Company, Ltd., to proceed with the construction of its synthetic rubber plant, which is now in production.

RESEARCH in the fundamental science and technique of synthetic rubbers has been studied at the Dunlop research centre over a span of years, as has also the development of the manufacture and the technology of the material. At the same time members of the company's scientific staff have observed the advances made in both Europe and America in synthetic rubber production and have advanced their own process development from that of the laboratory test apparatus to the pilot plant and on to the stage of small-scale experimental production. Dependence upon the import of raw materials has hitherto prevented further progress being made, but the construction of oil refineries and allied chemical plants in this country in recent years has removed this handicap by providing the necessary supplies of the raw materials, butadiene and styrene. The availability of these materials has made it possible for the company to proceed with the design and construction of a plant to produce synthetic rubber on a small manufacturing scale.

The new plant, which has a projected output of 1500 tons per annum, and has been built at Fort Dunlop, Birmingham, is based upon the experience gained during the years of research. A site of 12 acres is occupied by the plant, the main building of which covers an area of approximately 11,000 square feet. General supplies of air are provided at 80 lb per square inch from Fort Dunlop, but instrument air is supplied at 20 lb per square inch by a "Broomwade" compressor. The main objective is the manufacture of general-purpose rubber for tyres, but the design of the plant has allowed for flexibility of operation so that it will be possible to produce new synthetic rubbers as they are developed by the Central Research Division of the company, and also to experiment with process and plant modifications.

Ordinary synthetic rubber is built up from the monomers butadiene and styrene, both of which are highly reactive, and the process is outlined in the flow chart reproduced herewith. The styrene is delivered to storage at the isolated tank farm, and also the butadiene which is stored under nitrogen and under a pressure which varies according to the outside ambient temperature, the pressure rising as the temperature rises. From the farm the butadiene is piped to the monomer pretreatment plant, which consists of a vertical cylinder which is not packed but is equipped with a turbo-stirrer mechanically sealed ; it can be seen to the right of our illustration showing the main building. Here, the butadiene is washed with caustic soda to remove polymerisation inhibitors and the operation is carried out on a batch process. There is also a small distillation plant to purify any monomer which cannot be treated with caustic soda and so adds flexibility to the plant.



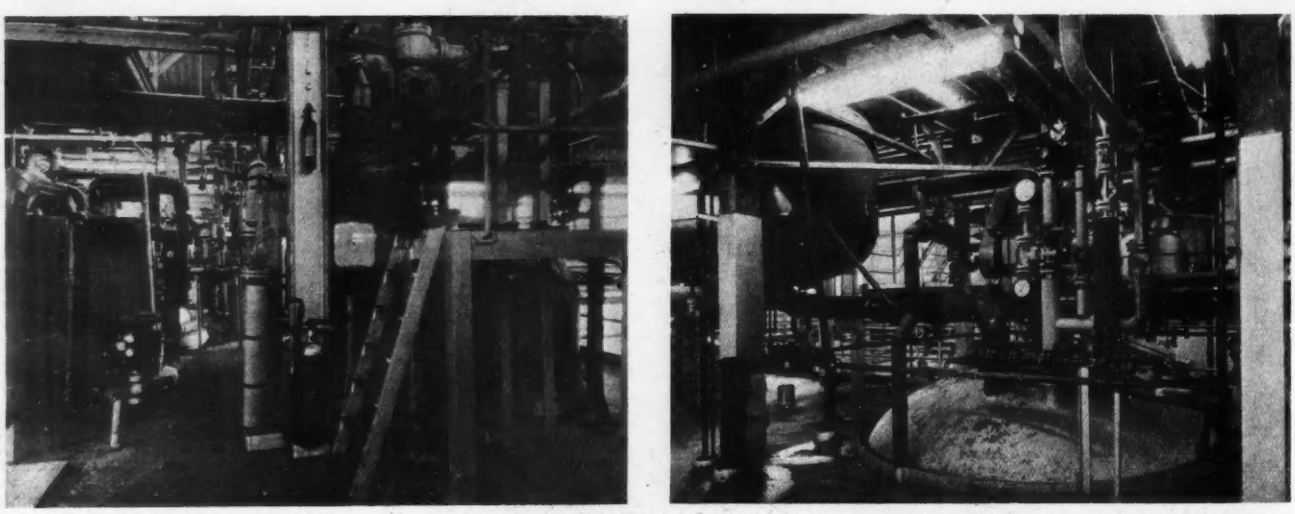
Synthetic rubber plant flow chart

Both the monomers are fed to the reactors, of which there are two full-scale units of 1400 gallons, and one-half scale unit of 700 gallons and one of 110 gallons. The reactors are glass lined and lagged and fitted with three-step variable-speed mechanical stirrers having a speed range varying with the size of the reactor. A special area is allocated for the preparation of soap emulsifiers, which are pumped in metered quantities through a heat exchanger to the reactor. The dilute soap solution, a catalyst and an initiator are added to emulsify the monomers. This emulsion forms crude latex plus unreacted styrene and butadiene, the time taken varying from eight to twelve hours and the polymerisation taking place at the controlled temperature suitable for the particular rubber product required. The crude latex leaves the reactors, which are jacketed, and brine circulated and passes into a blowdown tank, where a reaction arrester is added and then on to a two-stage flash tank, where the pressure is reduced to 3 lb per square inch and then to 200mm absolute, and the unreacted butadiene is flashed off from the unstripped latex and then recycled. This stage marks the end of the batch process and the beginning of the continuous process. Part of the reactor area can be seen in our illustrations below.

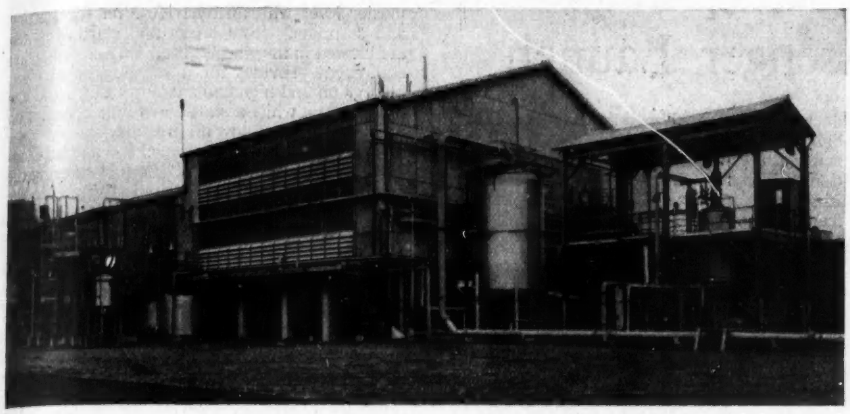
Partially stripped, the latex passes through a prefoamer, where it is warmed by steam injection, before entering the top section of a column, fitted with a series of perforated trays, to which low-pressure steam is admitted at the bottom. In the column the unreacted styrene is stripped from the latex, which is piped to storage, while the steam and styrene under vacuum provided by a Nash Hytor two-stage water ring pump are condensed and then passed on to two Balfour stainless steel receiver separators. Here the styrene rises to the surface of the water, which is drawn off while the styrene is returned for recycling. As required, the stripped latex is pumped to the coagulator, and to it is added an acid solution and brine which has been prepared in the area where the soap solutions are made up in vessels of stainless steel, wood and glass fibre. In the coagulator is a sulphuric acid solution, which is maintained at a constant pH value.

The coagulated crumb is forwarded via a vibrator, where it is freed from any surplus serum, to a chute and a second vibrating screen on to a belt conveyor. Here the crumbs of synthetic rubber are washed and passed to a set of squeeze rolls and converted into sheet, only to be immediately shredded back to crumb in a British Jeffrey-Diamond swing hammer mill. A conveyor of dredger pattern raises the crumb to the top of a three-pass three-level dryer using steam-heated air at 180–190 deg. Fah. The dried crumb is fed by conveyor to an automatic bagging machine or to the hopper of a Fielding automatic hydraulic baling machine fitted with Avery pneumatically controlled weighing equipment. Each bale is dusted with soapstone and then wrapped in polythene-lined paper bags preparatory to despatch.

Ancillary equipment at the Fort Dunlop plant includes a unit to produce nitrogen for purging the butadiene and styrene vessels, and refrigerat-



(Left)—Part of reactor area with the top of reactor to the right and heat exchanger on the left. (Right)—Reactor area showing the bottom of the reactor to the left and the top of the blowdown tank to the right



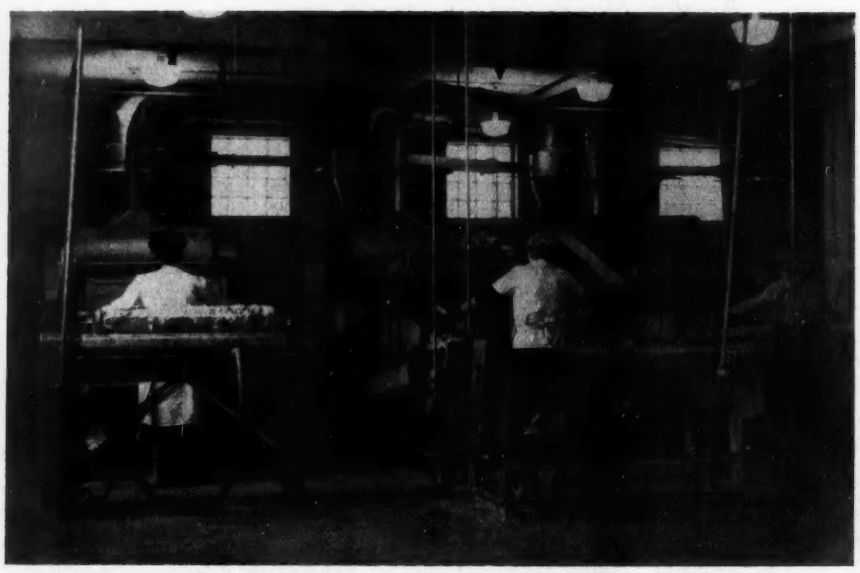
Exterior of main building with the monomer pretreatment plant shown to the right

ing machinery consisting of three ammonia compressors, rated at 382,000 B.Th.U. per hour. There is also a pump house for dealing with the circulation of cooling water and a laboratory for carrying out the necessary tests on the product.

Co-ordination of the project and process design has been the responsibility of the Central Research Division, while the Dunlop Architect's Department has been concerned with the design and construction of the buildings and the civil work on the site. The Fort Dunlop engineers provided all utilities, and fire protection equipment and the fire-fighting equipment was supplied by Mather and Platt, Ltd. The main contractor was Foster Wheeler, Ltd., the associated subcontractors being: John Toon and Partners, Ltd. (pipework), Allen Erection and Engineering Company, Ltd. (steelwork), Harris and Sheldon, Ltd. (electrical equipment), and Joseph Nadin, Ltd., (insulation). The building contractor was Robert M. Douglas (Contractors), Ltd.

Thermal Insulation Factory

A NEW factory recently occupied by Dick's Asbestos and Insulating Company, Ltd., at Thames Road, Silvertown, London, E.16, has enabled the firm to re-equip and extend its production lines to permit an appreciable increase in its manufacturing capacity for thermal insulating materials. This company is one of the oldest in the asbestos industry; it was established in 1874 by Mr. William Dick for the manufacture of asbestos compositions and engine packings. In 1916 it became a private limited company and in 1952 became a wholly owned subsidiary of Thos. W. Ward, Ltd., of Sheffield. The new factory has been organised and equipped for the manufacture of the insulating materials in powder or preformed sections, packings and jointings, in which the firm specialises, and it provides a centre for the company's contracting division which carries out all kinds of thermal and refrigeration insulation work. A great deal of work is undertaken by the firm in the development and manufacture of materials for special applications, one such job recently carried out being the insulation of a plant where operating temperatures were of the order of minus 200 deg. Cent.



Forming machines for making asbestos sectional pipe insulation

The works has a main two-storey building providing office accommodation and about 30,000 square feet of productive floor area. An extension already in hand will add another 10,000 square feet to the productive area, and there is provision on the site for a further large extension. The upper floor provides storage accommodation for raw materials, which are batched at appropriate stations and delivered to hopper loading points connected by chutes to processing and mixing equipment on the ground floor.

At one of the loading points there are batched the various powdered materials required for the compositions, which are mixed with water on site and applied in plastic form. These materials are mixed either in a ½-ton continuous mixer or a 2 cwt capacity tumbler before being weighed and bagged ready for delivery. At another station the semi-processed amosite asbestos fibre is unloaded into a hopper to gravitate down a chute into a hammer mill for final reduction to a suitable working condition. A majority of this fibre is used in the manufacture of preformed sectional insulation for pipework—an application for which amosite asbestos is particularly suitable, as apart from its low thermal conductivity, it has a temperature resistance of 1000 deg. Fah.

The use of this preformed sectional pipe insulation has grown considerably in recent years, as it does not call for any of the particular skill in application which is required when insulating with the plastic materials. It is made to suit pipes of any size and is supplied in standard 3ft lengths, split longitudinally to facilitate fitting on pipes. In the process of manufacture the asbestos fibre is delivered from a feed station adjoining the hammer mill to the hoppers of any one of a group of pipe-forming machines. Some of these machines are shown in the accompanying illustration. From the hoppers the fibre drops at a controlled rate on to a moving feed band, and as the mat of loose fibre is brought forward towards the operator it is sprayed with silicate of soda by a line of rotating brushes. At the front of the machine the asbestos fibre is picked up by and adheres to a rotating mandrel on which it is compressed to the required degree by a driven roller below. The required thickness of the fibre deposit is determined by a gauging flange at each end of the mandrel. When the mandrel carries a sufficient thickness of fibre it is transferred to finishing rolls in front of the machines, where it is sprayed with more silicate of soda and its surface is smoothed. This process imparts a hard, smooth surface to the insulating sections whilst leaving relatively loose cellular inner formation. The mandrels are then removed and the sections are dried in large ovens before being split longitudinally on a band saw prior to dispatch.

For low-pressure steam and hot water pipes a grey felt preformed sectional lagging is also made by the firm. In this case the sections are built up on rotating mandrels from sheets of material and after drying are split longitudinally on a circular saw.

In addition to its industrial products the firm has in the past year or so been making insulating jackets for use on domestic or small industrial tanks and cylinders to conserve heat in hot water systems. For making these jackets a large cutting and sewing room has been laid out on the upper floor of the factory. Each jacket consists of a fabric case with a thick woollen lining intersewn, and provided with tapes for tying on to a tank. The sections of the jackets are sewn together in such a way that holes can be made where necessary, to accommodate pipes leading into the tank, without loss of the insulating lining.

A sheet metal working shop, in addition to fabricating and preforming insulation sheathing for erection on site, is also equipped for fitting the protective metal sheets on road tankers after they have been insulated at the works. At present the accommodation for handling these tankers for special liquids is somewhat restricted and a large area of the extension now in hand is to be allocated for this class of work.

INTERNATIONAL CONGRESS ON COMBUSTION ENGINES.—The British National Committee, 6, Grafton Street, London, W.1, of the International Congress on Combustion Engines, has announced that a congress is to be held in Zurich and that the technical sessions will begin on Monday, June 17, and close on Saturday, June 22. Fees for the congress are 100 Swiss francs for gentlemen and 70 Swiss francs for ladies. The theme of the congress is "Supercharged Diesel Engines and Combustion Turbines in Various Spheres—Marine, Traction and Power Stations," and the meetings will be held in the Auditorium Maximum of the Swiss Federal Institute of Technology.

High-Speed Passenger Launch

FOR transporting engineers and technicians and drilling staff to the various drilling rigs in Lake Maracaibo, where the Cia Shell de Venezuela is conducting extensive marine drilling operations, the company ordered three fast passenger launches. They will operate on the 8000 square mile lake, and the first of the three built by John I. Thornycroft and Co., Ltd., at Southampton, recently completed its trials, when a mean speed of 31·2 knots was recorded. Since some drilling operations extend up to 40 miles from the shore, considerable time is spent in transporting the crews, and to reduce this to a minimum the new craft have a speed of 30 knots. The necessary power is provided by two nine-cylinder, two-cycle Napier "Deltic" diesel engines, each rated at 865 s.h.p. The launch has a length of 68ft 3in by 17ft 5in beam by 9ft 4in moulded depth and a draught of approximately 5ft 6in, and carries forty-five passengers.

Of hard-chine design, the launch, shown on trial in our illustration, has a raking stem and transom stern, and the hull is divided into four watertight compartments, namely, fore peak, passenger cabin, machinery space and steering gear compartment. Mild steel has been used for the main hull, bottom strakes of bulkheads and framing, while aluminium alloy has been employed for the main deck, passenger flat, bulkheads and superstructure, which consists of a raised roof over the passenger cabin and a wheelhouse shelter. In way of the propellers the bottom plating is ¼in thick and panting strips are arranged from the forward machinery space bulkhead to the fore peak, while the deck aft is stiffened to carry cargo and equipment.

The passenger cabin is equipped with twenty-three upholstered seats all facing forward and arranged in three groups, one to port, one to starboard, and one on the centre line, and mounted on platforms raised above the gangway flats. There is a toilet compartment forward. Natural lighting is by fourteen sliding horizontal windows at the sides and three 9in diameter lights in the forward apron, while ventilation of the compartment is effected by three trunks leading from the front of the wheelhouse and two exhaust fans. Three "Kent" clear-view screens are fitted in the forward windows of the wheelhouse, in which there are seats for the helmsman and two look-outs and four passengers. "Mathway" steering gear is fitted and connected to twin balanced-spade rudders and "Teleflex" engine controls.

Soundproofing material is applied to aft side of the forward bulkhead of the engine, which has natural ventilation and is fitted with "Pyrene" dry chemical fire-fighting equipment. An "Airpel" hand bilge pump is provided for clearing bilge water from the various compartments, and other gear includes a 55 lb Danforth anchor and ½in short-link chain, two searchlights and a floodlight, and a 200Ah, 24V, lead-acid battery, which is charged by two 720W, C.A.V. dynamos. There is a fresh water tank of 25 gallons capacity and in the steering compartment are two fuel tanks and a reserve tank, having a total capacity of 350 gallons.

Machinery Space

Access to the engine-room, a general view of which is given in our illustration, is through a hatchway in the main deck, and to suit the beam of the boat the two nine-cylinder, two-stroke, compression-ignition, opposed-piston Napier "Deltic" engines are staggered, the starboard engine being 2ft 9in further forward than the port. Over each engine is a portable aluminium alloy hatch cover flush with the casing top. An ahead/astern reduction gearbox is fitted to each engine, both being rated at 865 s.h.p. at 1500 r.p.m., but derated to 810 s.h.p. in the conditions prevailing in Venezuela. The engines drive outward turning three-bladed propellers of nickel aluminium bronze at 712 r.p.m., and the shafting is supported in fabricated mild steel "A" brackets fitted with "Cutless" rubber bearings. The engines consist of three cylinder blocks assembled with three crankcases to form an inverted triangle, held together by long, high-tensile, through bolts. Wet liners are fitted and one piston of each opposed pair of piston controls the exhaust ports, the other, the inlet ports. Each crankpin carries, on its plain rod, the inlet piston of one cylinder bank, and on its forked rod the exhaust piston of another bank. Both the top crankshafts are identical, but the crank-throws on the bottom one are opposite handed to suit the direction of rotation. The total output is combined in a phasing gear casing to which the ahead/astern reduction gearbox is directly bolted. A power take-off shaft and the drives for the centrifugal scavenge blower and other auxiliaries are provided by the phasing gearing. The former is placed at the free end of the engine and driven by a torsionally flexible shaft running through the cylinder block.

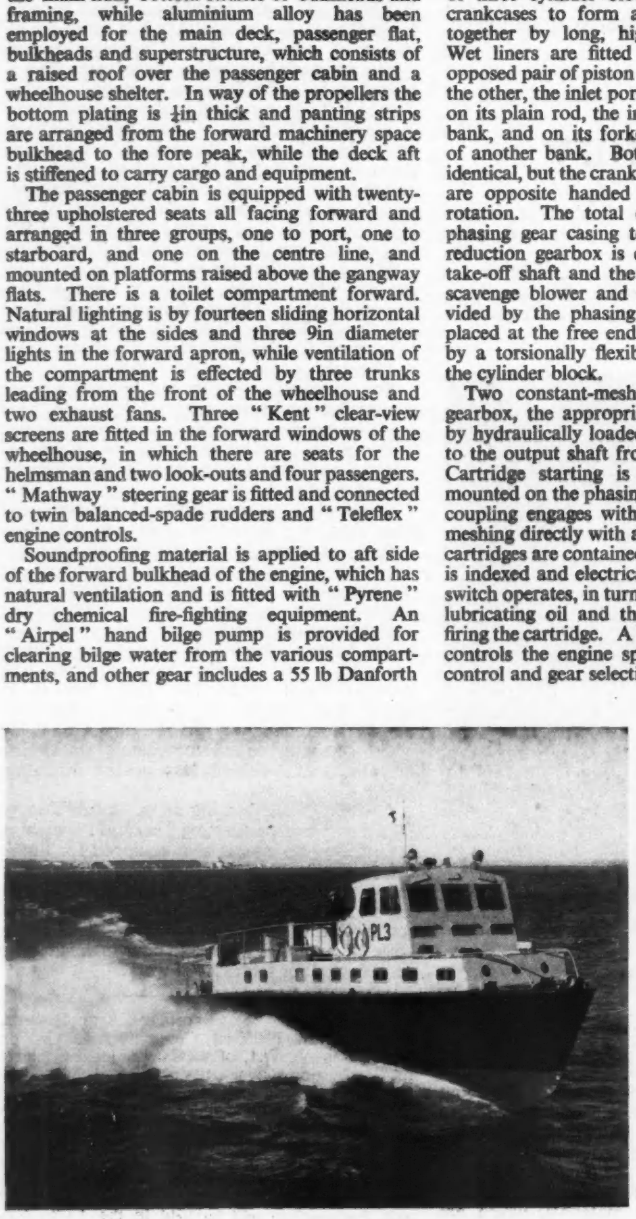
Two constant-mesh gear systems form the gearbox, the appropriate train being connected by hydraulically loaded plate clutches connected to the output shaft from the phasing gear train. Cartridge starting is fitted, the starter being mounted on the phasing gear casing, and its claw coupling engages with a similar one on a gear meshing directly with an upper crankshaft. Five cartridges are contained in a rotary breech, which is indexed and electrically fired, and the starting switch operates, in turn, the priming of the engine lubricating oil and the fuel oil systems before firing the cartridge. A Napier hydraulic governor controls the engine speed and both the engine control and gear selection are effected by a single master lever with an override lever for starting and stopping. Both levers and starting switch are located in the wheelhouse. Engine protection equipment provides for a warning being given on high oil and high coolant temperature and low oil pressure, while a shut-down unit operates on over-speeding and low oil pressure.

Varley gear pattern combined fuel and lubricating oil pumps are provided, the fuel entering the engine system at a self-sealing coupling, the excess fuel from each cambox being returned through a common pressurising valve to the tank. Lubricating oil is supplied under pressure and returned from the sump to the tank by a scavenge pump. Engine cooling is by a closed distilled water system, the water being circulated through a heat exchanger by a centrifugal pump mounted on the engine. An engine-driven pump circulates sea water through the lubricating oil coolers and the engine coolant heat exchangers. Thermostatically controlled by-pass valves allow for quick warming up of the engines, and to assist the intake of circulating water internal scoops are fitted to the hull. Air for the engine is drawn through an intake silencer from the machinery space and the exhaust gases are conducted through flexible steel pipes, three per engine, to Burgess silencers, and discharged at the ship's side.

Each engine is mounted on four brackets and the engine feet are in the form of a pack of metal-to-rubber-bonded discs, with a central spindle taking the weight. An intermediate shaft having internally toothed gear couplings connect the gearboxes to the Michell thrust blocks.

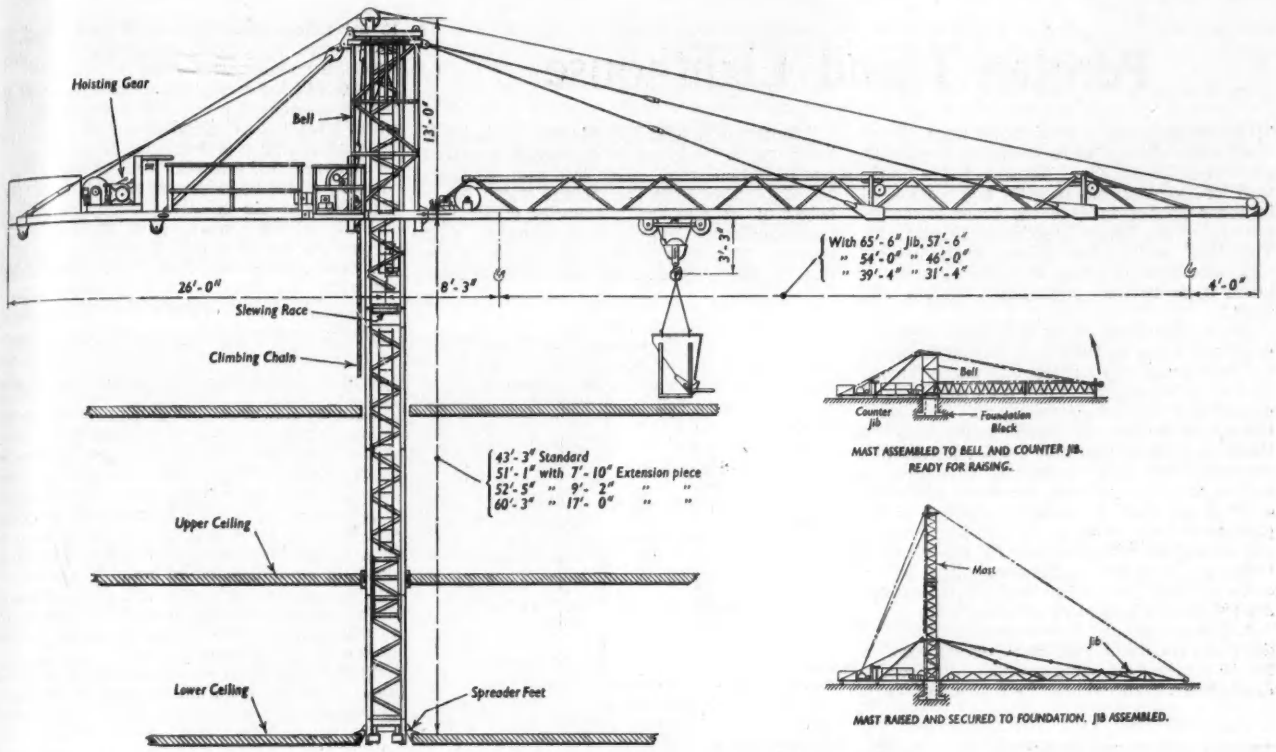
Technical Report

Annual Bulletin of Electric Energy Statistics for Europe. Geneva: United Nations Economic Commission for Europe. Available in bilingual edition, English-French, from the Sales Section, European Office of the United Nations, Geneva, Switzerland, or may be ordered through Sales Agents for United Nations Publications: H.M.S.O., P.O. Box 569, London, S.E.1. Price 1s. 9d.—The United Nations Economic Commission for Europe (E.C.E.) recently published its first Annual Bulletin of Electric Power Statistics for Europe. It contains final data for the years 1938 and for 1950 to 1954, as well as provisional data for 1955. The data are for Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Eastern Germany, Finland. France, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Roumania, Sweden, Switzerland, Turkey, Union of Soviet Socialist Republics, United Kingdom, United States of America, Western Germany and Yugoslavia. Tables give the maximum net capacity in continuous operation (situation at December 31 of each year); fuel consumed in electricity generation; international exchanges of electric energy during 1955; imports of electric energy during 1938 and 1951–1955; exports of electric energy during 1938 and 1951–1955; production, international exchanges and gross consumption of electric energy and average efficiency of thermal plants; and consumption of electric energy. All the data contained in the Bulletin have been directly supplied by governments to the E.C.E. Secretariat.



High-speed passenger launch for Lake Maracaibo on trial

Looking forward in the engine-room with hatches removed



Arrangement of self-erecting climbing crane and method of erection

Self-Erecting Climbing Crane

A SELF-ERECTING climbing crane, now being made under licence by Abelson and Co. (Engineers), Ltd., Coventry Road, Sheldon, Birmingham, 26, is intended for use when working on buildings taller than can be provided for by a rail-mounted tower crane or where restricted site conditions make the use of a floor-mounted tower crane impracticable. This design of crane can be used on buildings up to about 420ft high, if necessary. It can either be supported from a convenient base mounting at floor level in a low building or "climb" as building progresses, leaving the lower floors clear for other work to proceed whilst it is supported in successive "lifts" from the floors above. The capacity and working ranges of the crane are given in the accompanying table, whilst its general design can be seen in the drawing.

Lifting Duties of Crane

Radius	Up to 65ft 6in	Up to 32ft 6in	Motor
Load	1½ tons	2½ tons	—
Hoisting speed	196 f.p.m.	98 f.p.m.	18 h.p.
Slew speed	1·2 r.p.m.		3·8 h.p.
Trolley travel speed ...	115 f.p.m.		1·8 h.p.
Climbing speed	3 f.p.m.		3 h.p.

Maximum working height, normal, up to 262ft
Weight of ballast 2 tons 6 cwt
Alternative jib length 54ft, 39ft 4in
Alternative mast insertions, 7ft. 10in, 9ft. 2in., 17ft

All motions of the crane, including erection and climbing, are motor driven and the crane operator carries a low-voltage portable remote control panel on a 70ft long lead. With this form of portable control the operator has a wide range of movement, so that he can always place himself in the best position for controlling and observing loads. The panel incorporates an overload warning device and a locking key which can be removed to immobilise the crane and prevent unauthorised operation. The hoisting and slewing motions are regulated by miniature tramway controllers and the trolley and climbing motors are push button operated.

The method of erecting a crane is shown by the two small diagrams on the right of the drawing.

When the necessary foundation block has been prepared a mast foot is bolted on and a box-shaped structure, known as the "bell," is set in position over it. To this bell there is then bolted the counter jib of the crane, which incorporates the hoist gear and a ballast box, a rigid brace being connected between the middle of the jib and the top of the bell and a stay rope between the outer end of the jib and the bell. The main mast sections are then assembled in line along the ground in front of the foundation block. This mast consists of structural box sections, the upper one of which is mounted on a slewing race and a head section incorporating a sheave. Using a hoist rope from the counter jib winch and a special arrangement of reeving over the top of the bell, the mast can then be pulled upright and its foot bolted to the foundation block. One side of the bell removed for this operation is then replaced and the main jib is assembled in the space previously used for the mast. This main jib is attached by its pins to the bell in line with the counter jib. Support stays inserted between the jibs and the bell complete the head assembly of the crane.

The bell and jib assembly is raised and lowered on the mast with the use of a "climbing" chain, which can be seen suspended through a rod from the mast head in our drawing. This chain passes over the pinion and reversing rollers of a driving gear on the bell, and its lower end is anchored at the foot of the mast. Using this climbing gear, the jib assembly is first raised about 3ft above ground level for the trolley to be fitted and its travelling and hoisting ropes to be reeved. The jib is then raised to the top of the mast and its bell is bolted to the top of the main rotating member. With the jib in its working position the climbing chain is released from the foot of the mast and its free lower length stowed away in a box on the bell.

When it is required to raise the bottom section of the crane mast clear of the lower completed floors of a building the climbing chain is refixed to the foot of the mast. The bolts securing the bell to the mast are then removed and the complete jib assembly is lowered until it rests on the last completed floor of the building, or on girders set across its framework if more convenient. When the foot of the mast is then unbolted from the foundation block the climbing chain gear can be used to raise the mast vertically through the framework of the bell. The mast is raised until its foot is level with the selected upper floor from which it is to be supported. and spreader feet are bolted to each corner. These feet pivot outwards to support the mast in the floor, and where the mast passes through the completed floor above it is wedged with wood chocks to provide the necessary rigidity for crane operation. The bell and jib are then raised by the climbing gear, as in the initial erection procedure, and bolted to the mast head ready for operation.

If it is required to insert additional sections to increase the working height of a mast, a similar procedure to "climbing" can be followed. In this case, however, new sections are inserted between the mast foot and the foundation and spreader feet are not required. By introducing additional sections to the mast the effective working height of the crane can be increased from the standard 43ft to 60ft.

In the design, provision is made for the ready dismantling of the crane without the use of ancillary equipment. The jib and bell assembly is first lowered on to the top floor of the building. Then using the hoist gear the mast is lowered down through the building for dismantling section by section at ground floor level. The jib, ties and counter jib are then detached from the bell and with the hoist gear and counter jib rearranged to form a light mobile crane, they are lowered to the ground. This crane arrangement is also used to lower the bell frame over the side of the building before the winch, under its own power, is lowered. The remaining pieces of equipment can then be dismantled into readily handled parts.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

TUBULAR FLUORESCENT LAMPS FOR GENERAL LIGHTING SERVICE

No. 1853 : 1956. Price 4s. This standard is a revised version of the 1952 standard for tubular fluorescent lamps. It applies to lamps known as MCF/U with preheated cathodes, used in switch-start circuits, and is essentially a specification for testing batches of lamps for quality and interchangeability. An appendix to the standard contains detailed requirements for the colour, appearance and colour rendering of the light, and describes methods of testing.

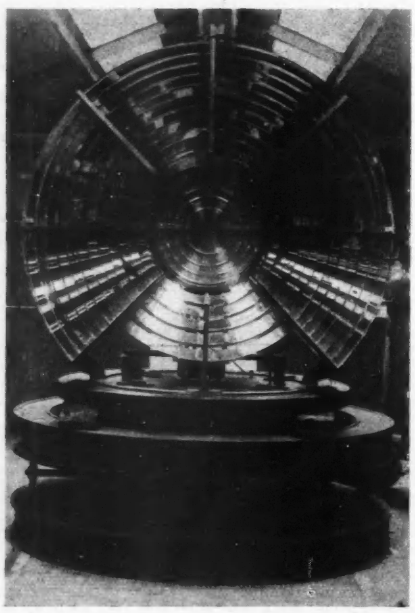
It does not include provisions for assessing the quality of the whole product of a manufacturer, but specifies methods of selecting lamps for testing, and stresses that the tests apply only to the individual batches.

Perotan Island Lighthouse

THE manufacture of a lighthouse assembly for Perotan Island, situated on the north-west coast of India and about 300 miles to the north-west of Bombay, has recently been completed by Stone-Chance Ltd., to the order of the engineer-in-chief, Indian Lighthouse Department. The third order, two panel, single flashing apparatus consists of the optic, pedestal, illuminant, optic rotating mechanism, lantern and spares.

The optic, of which we reproduce a photograph and a line drawing, is of 500mm focus and has two equal and symmetrical panels having their axes 180 deg. apart and each consisting of ground and polished glass elements. Each panel has a bulls eye lens with five refracting rings and there are twelve upper and five lower reflecting elements, the latter being of straight-down section so as to provide maximum space for entering the optic from below. The total net glass area of the refractors is 2240 square centimetres, the corresponding area for the reflectors being 19,700 square centimetres. The setting of the prismatic elements allows for dip to horizon due to height of focal plane above sea level.

A Chance mercury float pedestal is fitted and the optic is rotated once every twenty seconds by the rotating mechanism, which is of weight-driven pattern, and will run for a period of about

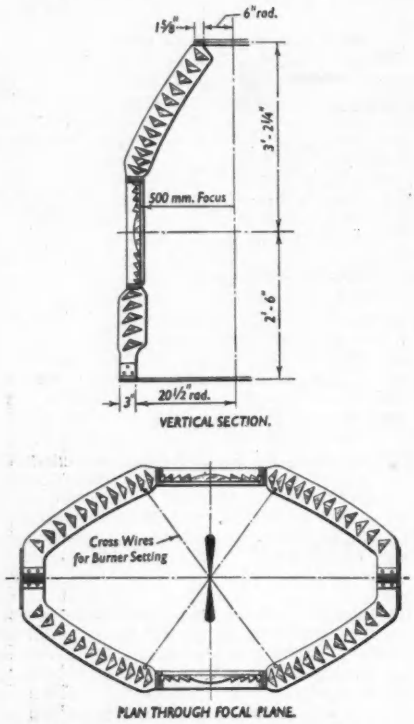


One panel of the 500mm focus optic

3·5 hours without rewinding with a direct fall of 30ft. The actual rate of fall of the weights, which are of cast iron and fitted on a steel rod, is 9·25ft per hour direct. A centrifugal governor maintains the speed of the clock within ±1 per cent of the nominal speed, while a self-maintaining gear ensures that the optic continues to rotate during the rewinding operation. A galvanised stranded steel driving rope is supplied and a dial indicator enables a check to be made on the speed of the optic. For use in the event of an emergency arising, the output shaft of the clock is provided with hand turning gear and, to warn the light-keeper when the weights approach the lower limit of travel, there is a battery-operated alarm bell.

A P.V. "Autoform" mantle burner of 55mm pattern forms the light source, which has a brightness of 49 stilbs, a width of 5cm and a height of 4·5cm. Oil consumption per hour amounts to 0·74 litres and the "autoform" burner has a power of 1205 candelas. The horizontal divergence of the light is 5 deg., 43 min., and the vertical divergence is 5 deg., 9 min.

A lantern having 8ft 9¾in diameter of glazing is fitted and is made up of a murette, a glazed portion and a roof. Ten cast iron segments bolted together form the murette which has a height of 7ft 2¾in and a diameter of 8ft 1⅞in inside the line of the webs of the segments. One segment contains a door giving access to the lantern gallery and there are nine circular



General arrangement of third order 2×180 deg. panel single flashing optic

ventilators protected by external cast iron cowlings and fitted with fine mesh insect gauzes. The lower sill and holding down flange are cast integrally with the segments. Ten panes of ¾in thick polished plate glass form the glazed portion, which has a clear height of 5ft 6in. The vertical glazing standards are bound at the top by a combined upper sill ring and gutter which consists of bolted segments of cast iron and supports the roof rafters. Copper sheets bolted to the rafters form the conical roof, which is surmounted by copper ventilators fitted with insect gauzes and a wind vane.

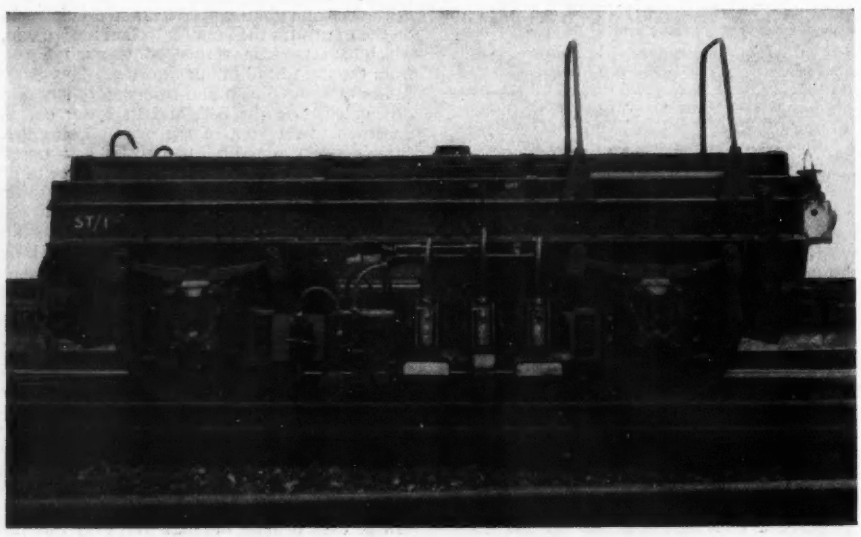
As mentioned earlier, the speed of rotation of the two-panel optic is once every twenty seconds, which gives a total period of ten seconds made up of a white flash of 0·35 seconds duration and an eclipse of 9·65 seconds. The stationary beam intensity of the optic is computed to be 883,000 candelas and the effective or apparent beam intensity of the lantern, after allowing for a lantern glazing absorption factor of 0·8 and a Blondel-Rey correction factor of 0·7, is 495,000 candelas. The range of the optic under normal moderately good atmospheric conditions is about 30 miles.

Sleet Tenders on London Transport

LONDON TRANSPORT has developed a new form of sleet tender designed to prevent winter train delays due to conductor rail icing. These sleet tenders are arranged for attachment to the front and rear of an empty service train, and the first to be completed is illustrated below. The tenders will fulfil the function of the present sleet locomotives, of which the traction control equipment, now out of date, would be costly to modernise. Apart from the much lower initial and maintenance costs, the new design of tender has a particular advantage over a sleet locomotive in that no special crew is required.

Each tender is of restricted height to afford an unimpaired view from the train driver's cab, and consists of a specially constructed four-wheel bogie. To this bogie is fitted de-icing equipment similar to that of a sleet locomotive—three sets of crushing rollers, steel brushes and de-icing sprays. One of the three sets deals with the central negative rail and one of the other two with the positive rail, according to which side of the track it is located. Compressed air from the train system is used to lower the rollers and brushes into contact with the rails against the pressure of the return springs. The sprays are fed by an axle-driven pump from two inter-connected 75 gallon tanks mounted on top of the bogie frame, and the de-icing fluid is delivered on to the rails at the rate of 0·9 gallon per mile. The pump is cut out as required by the disengagement of a lever-operated dog clutch. To avoid damage to the pump in the event of all three sprays becoming blocked, the delivery pipe is fitted with a relief valve from which the fluid is returned to the tanks.

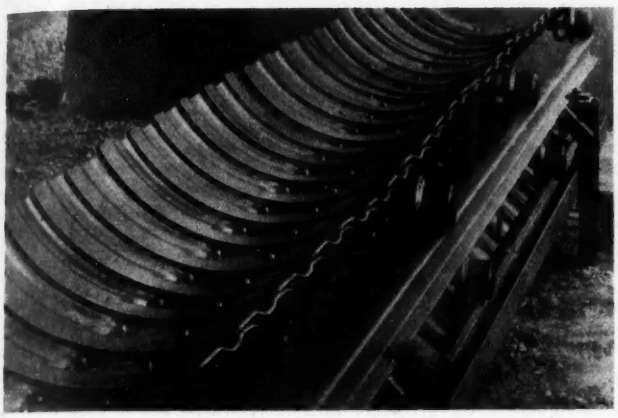
As the location of the positive rail varies from side to side of the track, a selector, in the form of a mechanically operated cut-off valve, is provided on each side. This valve is operated by a lever carrying a small roller which rides on the positive rail. When the roller drops below a predetermined level at the rail end ramps the spray on that side is cut off. The tender is fitted with a spring-applied brake, which is normally released by air pressure.



Sleet tender for de-icing track on London Transport's rail system

Steel Conveyors

THE manufacturing rights for a conveyor of all-steel construction, hitherto made only in Germany, have been acquired for this country and the Commonwealth by Wharton (Engineers), Ltd., Watford Road, Elstree, Herts. A section of one of these conveyors is illustrated on this page. The conveyors consist of a series of overlapping curved steel pans attached to each other by a central driving chain below. Brackets fitted at intervals along a line of pans are fitted with spindles on which rollers run on anti-friction bearings. Through these rollers the line of conveyor pans is supported on a track built up from standard narrow gauge rails.



Conveyor of all-steel construction, built up of overlapping curved steel pans connected by a central driving chain, and supported through rollers on rail track

The conveyors can be readily arranged to negotiate curves, and the method of rail support provides a steady platform for the material being carried. On relatively short radii curves the supporting rollers are held in contact with the track rails by lengths of guard rail. Each conveyor is driven by electric motor through transfer and reduction gearing and sprocket chain at the head end, and a tail unit incorporates an idler sprocket with provision for driving chain tensioning. The main frame connecting the head and tail units is built up of a rigid framework, with fabricated angle bridge members locating and supporting the upper and lower sets of rails for the delivery and return sides of the conveyor. The frame is made in suitable lengths to facilitate erection and dismantling, and for the lengthening or shortening of an installation as desired.

It is stated that the conveyors are suitable for conveying materials such as dry sand up gradients of 32 deg. and handling materials at up to 700 deg. Cent. Wharton (Engineers), Ltd., is at present manufacturing three sizes of the conveyors with pans 22in, 13in and 9in wide. These three conveyors, when operating at 200ft per minute, are stated to have respective carrying capacities of 488, 205 and 112 cubic yards per hour.

Flowmeter Testing

FUEL flowmeters were first introduced in aircraft as an addition to the established "fuel remaining" indication. The transition to turbines of high consumption made the rate of consumption more important, while the increase in flight speeds has forced the fuel into numerous shallow tanks in which contents measurement is difficult. Thus the system in use in some current military jet aircraft is to rely entirely upon the flowmeter readings, integrating the indications to find the total fuel consumed from the time of starting. Such flowmeters must be calibrated throughout their range, and the test equipment required to circulate up to 40,000 lb per hour at specified temperatures becomes extensive.

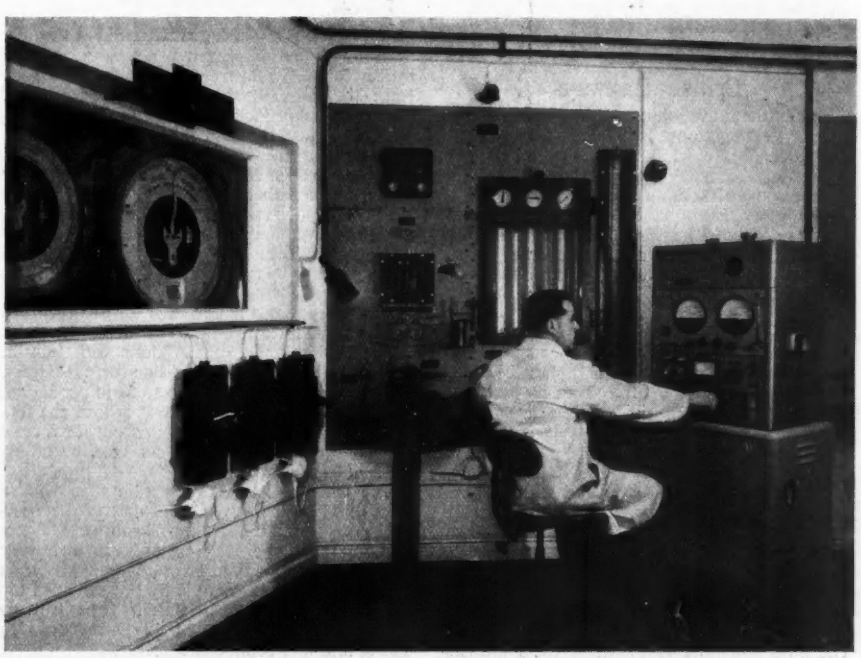
A test house to perform these tests was recently opened by Elliott Brothers (London), Ltd., at Rochester; it is isolated from the main works and is surrounded by turf intended to lay dust and to prevent spilt fuel running along the ground in the event of an accident. Immediately within the outer wall is a narrow room containing the pumps and associated equipment; the inner wall of this room carries the four test stands, and on the other side of it is the observation room, seen in the accompanying illustration. The fuel is stored in two 750-gallon tanks buried outside the building, and a separate boiler-house provides steam for heating. A refrigerating plant to keep the fuel at the required temperature is installed in the test building.

Each test stand has its own pump able to deliver 40,000 lb per hour of fuel at 30 lb per square inch. A pneumatic servo system maintains the pressure constant by returning excess fuel to the tank. Passing through a Phillips wire-wound magnetic filter, which removes particles down to 5 microns, the fuel enters and leaves the flowmeter transmitter through shut-off cocks; the flow is adjusted by hand by large, medium and small valves in parallel. It is then passed through a long-range "Rotameter," consisting of three glasses in series, the float in each rising clear of the tube when it has passed its maximum reading. The "Rotameter" can be calibrated by passing the fuel to the large or small weigh tanks, the scales of which can be seen on the left in the illustration.

The transmitters are mounted upon vibrators to simulate service conditions, and connections are provided for a mercury manometer to measure pressure drop through the transmitter. The output is monitored by electronic equipment mounted in a movable cabinet.

Elaborate precautions are taken to minimise the consequences of an outbreak of fire. Rate-of-rise of temperature detection devices are provided, and automatically actuate the extinguishing system, except in an occupied room, in which case they sound an alarm. The extinguishing medium is carbon dioxide, the release gear being energised by weights falling under gravity. In the event of an alarm, all electric services except lights are disconnected. All compartments which are occupied when in use have alternative exits. The boiler-house has a separate extinguishing system operated by a fusible link.

It is interesting to note that a single flowmeter transmitter can cover the range of three "Rotameter" tubes in series. This is because the moving part, a vane, is restrained by a spring of finite rate, and because the contour of the fixed part of the orifice is completely at the designer's disposal. The angle assumed by the vane is communicated to an amplifier, which signals it to individual indicators for each engine, and sums the signals for all engines and energises an integrating flowmeter. The transmitter, being not independent of viscosity, is compensated for changes in temperature. Present production is devoted to instruments calibrated for wide cut gasolene, but kerosene instruments can be supplied, and the recently developed 3000 lb-per-hour transmitter, being particularly suitable for turbo-prop engines, is likely to be used for this fuel.



The fuel flow transmitter under test can be seen mounted over the drip tray behind the operator. Above this and to the left is one of the nozzles of the carbon dioxide fire-extinguishing system. Behind the operator's head is the "Rotameter," and to his right the movable electronics cabinet

Spacing of Railway Sleepers on South African Railways

A PROGRAMME of research into the behaviour of railway track under load has recently been commenced by the National Building Research Institute on behalf of the South African Railways. The experimental work is being carried out in the structures laboratory of the Engineering Division, where a 40ft length of railway track has been laid down in accordance with current S.A.R. practice.

The investigations are aimed at obtaining information on the load-bearing capacity of the stone ballast and the distribution of stresses in the ballast and sleepers under various loading conditions. Initially the tests will involve the application of static loads to the track by means of 50-ton hydraulic jacks. However, at a later stage in the experimental programme it is hoped that it will be possible to investigate the behaviour of the track under more practical conditions of dynamic loading, either in the laboratory or under actual running conditions.

The object of this work is to study the sleeper spacing that is currently used by the South African Railways, as sleepers and the associated rail fixing devices are relatively expensive items, and an increase in even a few inches in sleeper spacing could result in a considerable reduction in costs.

Electronic Megaphone

A BATTERY-DRIVEN portable electronic megaphone with a range of about 400 yards in quiet conditions has been developed by Pye Telecommunications, Ltd., Cambridge. It has a maximum output of 3½W and an output, at less than 10 per cent distortion, of 3W. The amplifying circuit uses transistors and the average current consumption on speech is stated to be 120mA, giving a battery life of twelve hours' continual operation for 20 sec. on and 20 sec. off, or of six months with an average duty of 20 sec. per minute.

Electronic megaphone with a specified range of 400 yards in quiet conditions. Transistors keep the current consumption to 120 mA and give an average battery life of six months

The megaphone, which can be seen in use in the accompanying illustration, weighs 5 lb, has an overall length of 15½in and a diameter over flare of 10½in.

Prototype Passenger Coaches for British Railways

UNDER the railway modernisation plan British Railways expect to put into service about 20,000 new coaching vehicles during the seven years ending in December, 1962. These vehicles will include some 7700 main line coaches fitted with end gangways and suitable for haulage by steam, diesel or electric locomotives. For these new coaches British Railways, in collaboration with manufacturers, is seeking to improve travel comfort and amenities, and proposes to obtain public reaction to such things as improvements in heat and sound insulation, revolving and reclining seats, roomier compartments, and new designs of luggage racks and lighting fittings. To try out these details the British Transport Commission has authorised the construction of fourteen prototype main line passenger coaches, eight of which will be built by contractors and six by British Railways.

Under the contracts placed the Metropolitan-Cammell Carriage and Wagon Company, Ltd., and the Gloucester Carriage and Wagon Company, Ltd., will each build a corridor first-class and a corridor second-class coach; the Birmingham Carriage and Wagon Company, Ltd., and Cravens, Ltd., will each build an open first-class and an open second-class coach. The nine vehicles to be built at the Doncaster works of British Railways will include a corridor first-class and a corridor second-class coach, an open first-class coach with adjustable seating, an open first-class coach with fixed seating, and two modified existing designs of open second-class coaches.

In the interior design and decor of the prototype vehicles the contractors have been given an absolutely free hand to use their own ideas, or to utilise the services of independent design consultants, within the physical limits of the standard British Railways all-steel frame and body. The vehicles now nearing completion at Doncaster, however, will have interior layout, design and equipment based on a special study of future design by a panel of B.T.C. and British Railways experts, with detailed decor commissioned from a design group.

The first of the contractors' prototype coaches to be completed are the corridor first-class and the corridor second-class vehicles, for which an order was placed with the Metropolitan-Cammell Carriage and Wagon Company, Ltd. These two vehicles were shown to the Press at Marylebone Station last week. In them, a number of new ideas have been incorporated to increase the comfort of the passenger. There are six compartments instead of the usual seven in the first-class coach and seven instead of eight compartments in the second-class coach, thus giving increased space in each compartment and more leg room for each passenger. The vehicle shells have been sprayed with limpet asbestos to deaden noise and increase heat insulation properties. Double glazed window units are fitted to avoid condensation and assist in heat conservation. Plastic material used throughout for the interior finish is designed to give maximum wear with the minimum amount of maintenance, and mouldings have been kept to the minimum to eliminate dirt traps. A grill along the window ledge in each first-class compartment is designed to provide a blanket of warm air between the cold surface of the glass and the passengers. This arrangement also provides an effective demister for the windows. The corridors in both coaches are heated.

The first-class coach has individual high-back armchair seats, whilst the seats in the second-class coach are fitted with hinged arm rests. Each seat is provided with an individual reading lamp, whilst a general lighting system gives effective overall illumination. Separate lavatories are provided for ladies and gentlemen, and that for the ladies has a separate powder room. In each compartment decorative panels in plastics are fitted above the seats, the motifs being incorporated in the "Formica" veneers.

Air Cargo-Liner

A TURBO-PROP transport to carry either or both freight and passengers has been undertaken by Sir W. G. Armstrong Whitworth Aircraft, Ltd.; the first flight should take place next year, and the initial production will be ten machines.

The project bears a resemblance to such transports as the Nord "Noratlas," but both front and rear ends of the fuselage are closed by single doors with openings 8½ft wide and 6½ft high. The floor is at truck platform height, 4ft, when the aircraft is at rest, and extends 47ft by 10ft; payloads of 12½ tons can be carried. Up to eighty-two passengers can be seated six abreast, while the military version will take seventy fully armed troops, five abreast. Stores can be parachuted from the rear doorway, and a ramp may be built in. A door with built-in steps is provided in the port side for passengers, and the hull is pressurised up to 5½ lb per square inch by engine-driven blowers. Above the forward door is the flight deck, laid out for a crew of two or three, which is expected to afford unusually good visibility.

The wing, 1419 square feet in area with a span of 115ft, is derived from that of the Avro "Lincoln" or "Shackleton," another Hawker Siddeley product; the long operational history of this structure should enable fatigue problems to be avoided. De-icing is by hot air from the main engines. Double slotted flaps will be hydraulically operated, the flying controls having spring tabs and being cable operated.

The tail booms house the retracted twin main wheels and the inboard engines; two alternative power plants are projected, the initial machines, known as the A.W.650, having four Rolls-Royce "Dart" R.Da.7/2 engines of 2100 e.s.h.p. An alternative version, the A.W.651, may have two Rolls-Royce "Tyne" engines. The military variant, A.W.660, has the same four "Dart" engines.

Twin fins and rudders stand above the tail booms, and outside them are the horn balances of the elevator and a very small portion of tail plane.

The performance predicted includes cruising speeds up to 300 m.p.h., a range up to 2000 statute miles with 8 tons payload and take-off in 3500ft. The all-up weight will initially be 76,000 lb, but development should result in 82,000 lb at an early stage.

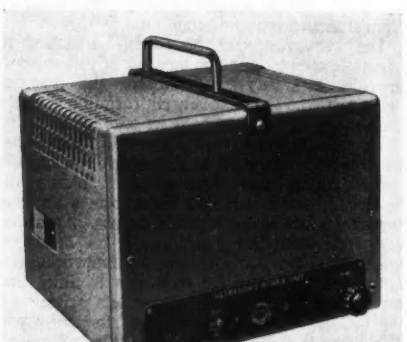
In addition to a proved wing and well-established engines the "Freightliner" will use only accessories and equipment known to give a satisfactory life in service. It is intended thereby to render it suitable for operation in remote territories and to obtain the maximum utilisation. Full certification to British and U.S. standards is sought.

A further variant is envisaged with a very wide unpressurised hull for employment as a car ferry, carrying up to six cars and thirty passengers.

Ultrasonic Generator for Drilling and Soldering Applications

A COMPOSITE low-frequency, ultrasonic generator "E7589" has been developed by Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1, to serve as a single source giving outputs suitable for driving the 50W ultrasonic drill, the soldering iron or the tinning bath made by the same company.

The "E7589" equipment is a dual-purpose generator which combines the functions of the existing generators, "E7685" for the drill, and "E7595" for the soldering iron or tinning bath. Two outputs can be taken from the new generator: one for the drill and one for the soldering iron or tinning bath. The former is transformer coupled to the transducer, the latter capacity coupled. The nominal output is 50W, and the ultrasonic frequency is variable by means of a single control up to 30 kc/s; the transducers incorporated in the drill, soldering iron and tinning bath are designed for operation at around 20 kc/s. The generator also provides a suitable supply for heating the bit of the soldering iron.



The composite low-frequency ultrasonic generator shown here constitutes a single source suitable for driving the 50W ultrasonic drill or the soldering iron or tinning bath made by Mullard, Ltd.

The method of connecting the various ultrasonic equipments to the generator eliminates any risk of wrong connection, or of damaging the generator by operating two equipments from it simultaneously. Six-pin and eight-pin sockets, respectively, terminate the drill and iron tinning bath outputs, and a sliding shutter masks the socket not in use.

As illustrated here, the generator is enclosed in a ventilated sheet metal case, which is fitted with a carrying handle and has the same overall dimensions as the separate generators—12in by 10in by 11in high.

Industrial and Labour Notes

Changes in Wage Rates

The Ministry of Labour has stated that changes in wage rates which were reported as becoming effective in December last resulted in an aggregate increase of approximately £93,0.0 in the weekly full-time wages of about 393,000 workpeople. Among those who received increases were iron and steel workers, ironstone mine workers and limestone quarrymen in certain districts. These increases were payable under sliding scale arrangements based on the index of retail prices.

According to a survey of wage movements, which is given in the January issue of the *Ministry of Labour Gazette*, the average level of full-time weekly rates of wages increased during 1956 by about 7½ per cent, compared with an increase of about 7 per cent in 1955, and of 4½ per cent in 1954. It is estimated that rather more than 12,500,000 workpeople received increases in rates of wages amounting at the end of last year to approximately £6,500,000 a week. Furthermore, during last year about 20,000 workers had their normal working hours reduced by an average of about 1½ hours a week. The index of weekly rates of wages (June 30, 1947,=100) stood at 166 for all workers at the end of last December ; for workers in the manufacturing industries only the index number was 164. It should be noted, however, that those indices relate to the level of full-time weekly rates of wages, and do not measure the changes in actual weekly earnings.

In a more detailed analysis of some of the principal changes in wage rates last year, the Ministry refers to the industries grouped under the headings "engineering, shipbuilding and electrical goods, vehicles, and metal goods not elsewhere specified." In this group, in 1956, the changes in wage rates resulted in increases aggregating £1,387,000 in the weekly full-time rates of 2,645,500 workers. The survey recalls that in March of last year in the engineering and allied industries men received increases of 12s. 6d. a week for skilled workers, 11s. for the intermediate grades, and 9s. 6d. for unskilled workers. Women on engineering rates of pay had an increase of 8s. 6d. a week. Corresponding wage increases for men in the shipbuilding and ship repairing industries were also introduced last March, together with increases ranging from 8s. 4d. to 12s. 6d. a week for women of twenty-one and over.

Industrial Disputes

During 1956, stoppages of work arising from industrial disputes in the United Kingdom resulted in a loss of about 2,083,000 working days at the establishments where the stoppages occurred ; of these, 2,036,000 were lost through stoppages beginning in that year and 47,000 through stoppages which had started in the previous year. The total number of days lost during 1955 was 3,781,000. The number of stoppages reported to the Ministry of Labour as beginning in 1956 was 2643, compared with 2419 in 1955.

Among the more important stoppages in the coal mining industry were two in Wales and two in Yorkshire, resulting in a loss of approximately 58,400 working days. In the iron and steel manufacturing industry approximately 200,000 working days were lost by about 5300 maintenance workers in various districts in Great Britain in a protracted stoppage lasting from June to August. In the ship repairing industry some 221,000 working days were lost in five major stoppages. Nearly 12,000 working days were lost in the engineering industry in April, when about 700 workers at Crawley ceased work on the manufacture of process plant and equipment. Stoppages in the vehicle building industry accounted for about one-sixth of the aggregate loss of time in 1956, and approximately another sixth was lost during February and March by some 16,000 workers in the printing industry. In the building and contracting industry about 14,000 working days were lost at Grangemouth oil refinery. Workers engaged in shipbuilding, engineering and aircraft manufacture in Belfast were involved in a short stoppage of work in February resulting in a loss of 13,000 working days.

Scottish Industry

Comments on the need to achieve a small increase in the overall rate of productivity are followed, in the annual statement of the Governor of the Royal Bank of Scotland, His Grace the Duke of Buccleuch, by a short review of Scottish industry and trade. He refers first to Scotland's staple industries in the shipbuilding and engineering field, upon which the well-being of so many of its people depend. These industries, the statement goes on, have had a good year and seem assured of a high level of activity for many years ahead. The whole world, says the Duke of Buccleuch, is now committed to a large shipbuilding programme, not only for tankers, which have figured so much in the news recently, but also for vessels of all descriptions. He remarks that this presents our shipbuilders with a wonderful opportunity to secure orders sufficient to keep the shipyards busy for a long time to come. The Duke of Buccleuch then stresses that shipbuilders must, however, maintain their efficiency at the highest level in order to keep their prices competitive with those of shipbuilders in other countries. The demand for steel products, he adds, both for home requirements and for overseas markets, continues to rise and, despite increased production, still remains unsatisfied.

Export Trade Monthly Figures

A change in the method of compiling the monthly statistics of export trade from the beginning of 1957 has been announced by the Board of Trade. The change is designed to reduce the variation in the number of working days covered each month, and to spread more evenly the work of the Customs Statistical Office. The number of part working days covered by the export account for a month in the past varied between twenty-three and twenty-eight, but since the volume of exports handled is fairly closely related to the number of part working days, this variation has given rise to movements in recorded exports unconnected with actual changes in the level of trade. Export account periods for 1957, states the Board of Trade, will be arranged to contain either twenty-five or twenty-six part working days, giving seven months of twenty-six working days and five months of twenty-five working days. Thus, in future, the number of working days will hardly affect the trend of month-to-month figures. Seasonal factors, such as summer holidays and closure of ports by ice, will continue to affect the level of trade.

Imports are less directly affected than exports by the number of working days in the month, and any effect is overlaid by the marked seasonality in arrivals of many important commodities. For this reason, states the Board of Trade, the period covered by each month's import account will continue to be the calendar month.

Continental Trade Fairs

The Birmingham Exchange and Engineering Centre has announced its decision to participate in three overseas trade fairs in 1957, following its successful participation in last year's Vienna Trade Fair. The three fairs are the Leipzig Technical Trade Fair, March 3 to 14 ; the German Industries Fair, Hanover, April 28 to May 7, and the International Autumn Trade Fair, Vienna, September 8 to 15.

In a statement issued last week, the committee of the Birmingham Exchange and Engineering Centre states that it would like all British exhibitors to take full advantage of the Centre's services, whether members or not, and to supply in advance to the Centre descriptive literature, in German if possible, on their products.

The fair authorities at Leipzig have invited the Engineering Centre to set up its office in the Messedienst, the fair headquarters. Visitors to the fair will be provided with information by the Centre, on sources of supply of British engineering products, and general information on the British engineering industry. In Hanover the Centre will co-operate with the Board of Trade in the British Government Enquiry Office, and will distribute literature and other information. In Vienna, the statement continues, the Centre will handle, by arrangement with the Board of Trade, all engineering inquiries received at the British Pavilion.

Planning Success

The presidential address to the Institute of the Motor Industry was delivered on January 31 by Mr. Stanley S. Dawes, M.I.Mech.E., whose theme was that a break in the cycle of rising costs and rising prices must be made by managements of greater ability. He announced two new residential courses at the College of Technology, Loughborough, one of two years common to the third and fourth years of the four-year Motor Industry Diploma course, and the other of one year and covering intensively the same field of administrative principles and practices. These courses were intended for engineering graduates and others, and should meet every requirement of the industry. For support these courses depended on the realisation by managers to-day that education and training are the very foundation upon which every successful enterprise is built. It was apparent at the present moment, when men in the industry were being called upon to face difficulties unprecedented since the war, that they should have at their command those with wide experience, understanding and balanced minds. Competent and well-trained administrators were not made overnight, but were the product of long-term policy. Those who advocated more effective industrial education were aware that there were obstacles in the way of a sustained flow of candidates for such courses as these : many young people, he believed, were not getting proper advice regarding the choice of occupations. Neither industry nor the trade unions could escape responsibility for a system in which wages were often out of proportion to the value of a job and little different for skilled and unskilled work. All those present were concerned with the problem of securing the best trained and most efficient personnel.

Coal

Coal production in Great Britain in the early weeks of this year has been better than it was during the comparable period of 1956. In the five weeks ended last Saturday total saleable output amounted to 22,506,500 tons, of which 21,417,600 tons came from the deep mines and 1,088,900 tons came from opencast sites. In the corresponding period of last year, output totalled 21,980,000 tons, which figure included 21,110,000 tons from the deep mines and 870,000 tons from opencast sites.

The overall manpower situation is a little better than it was a year ago. The average number of wage earners on colliery books in the first four weeks of this year was 706,900, which included 285,300 face workers. In recent weeks there has been a steady, though small, increase in the number of face workers, although the total is still below that of a year ago. "Absence percentage" was a little lower during January than it was at the same time last year, and there has been a small improvement in the figure for output per manshift at the face. The figures for coal consumption, which have been issued by the Ministry of Power, show that, in the first four weeks of this year, inland consumption, amounting to 19,149,000 tons, was rather higher than in the comparable period of last year, while the amount taken up by export and bunker requirements, 792,000 tons, was a little lower.

Coal imports in the first four weeks of this year amounted to 182,200 tons, compared with 635,500 tons in the corresponding weeks of last year. On January 26, distributed coal stocks totalled 16,089,000 tons, and undistributed stocks at collieries and opencast sites amounted to 2,805,000 tons.

High Speed Railcars for the Moroccan Railways

TO compete effectively with the service offered by air and road transport, long-distance rail routes must be served by passenger trains which provide speed, safety and comfort. Our accompanying illustration shows one of the railcar trains built by De Dietrich et Cie, Niederbronn (Bas Rhin), and Société Alsthom, for the Moroccan Railways. On its recent maiden voyage, the Dietrich-Alsthom train completed the run Paris-Strasbourg in 4 h 16 min, compared with a normal time of 5 h 5 min. It has an engine power of 8 h.p. to 10 h.p. per ton and offers exceptionally comfortable travelling conditions : armchairs which have adjustable backs or are transformable into couchettes, air conditioning, refreshment service, and passenger carriages separated from the engine units.

While De Dietrich was responsible for the passenger coaches, Alsthom built the motor carriages. The diesel engines were built by the Société Alsacienne de Constructions Mécaniques, Mulhouse.

In accordance with variations in the volume and nature of the traffic, and the special facilities required (day and night services, tourism, customs and police formalities to be carried out on the train, while crossing frontiers), it had been decided to use trains which could be made up in a variety of ways. Using one or two-motor carriages with compartments for baggage, the guard, the customs and the police, the rest of the train could consist of three to five special carriages of five different designs : second-class without service quarters ; second-class with service quarters ; first-class with bar ; couchettes with restaurant compartment, or lounge with couchettes and observation compartment.

This very flexible system makes it possible to make up 155-ton to 275-ton trains, capable of transporting 100 to 240 passengers.

Each motor carriage is equipped with a diesel-electric power unit of 1100 h.p. continuous rating, which is limited to 1000 h.p. in use and corresponds to 800 h.p. at the wheel rim. In addition, each motor carriage carries an independent auxiliary generator set rated at 210 h.p., limited to 180 h.p. in use.

Maximum design speed is 140km per hour on 1 in 66⅔ gradients with two motors hauling 275 metric tons, or 1 in 77 gradients with one motor hauling 155 metric tons.

The interior temperature is maintained constant in summer and winter by the Stone-Carrier system installed. Roof and walls are insulated by means of glass wool, and the windows are of double safety glass. The floor is insulated with sprayed asbestos.

First-class carriages have swivel seating with adjustable backs, and removable leg rests are provided for use during the night. Second-class seats have reversible backs, and are also adjustable as to inclination. The main lighting system is continuous fluorescent lighting, and incorporates a night lighting system of argon lamps. Passengers also have directable individual reading lamps. A public address system is installed.

Interior of second-class railcar. The seats are inclinable. The arrangement in first-class is similar, but with three seats per row instead of four

Meals are served at the passengers' seats on removable shelves which can be attached to the elbow rests. First-class passengers can visit the bar, which is furnished with armchairs and bar-stools.

The compressed air brakes (system Jourdain and Monneret) with a dry and wet-rail safety device, acts on four shoes per wheel (two of cast iron and two of "Flertex"). It can stop the train within 850m from a speed of 130km per hour.

All the passenger carriages are carried on "Y 187" bogies which have been tested in service on the S.N.C.F. system. The connection between axlebox and bogie is by inverted leaf spring, thus eliminating the maintenance and replacement of axle guides.

High-Pressure Axial-Flow Fan

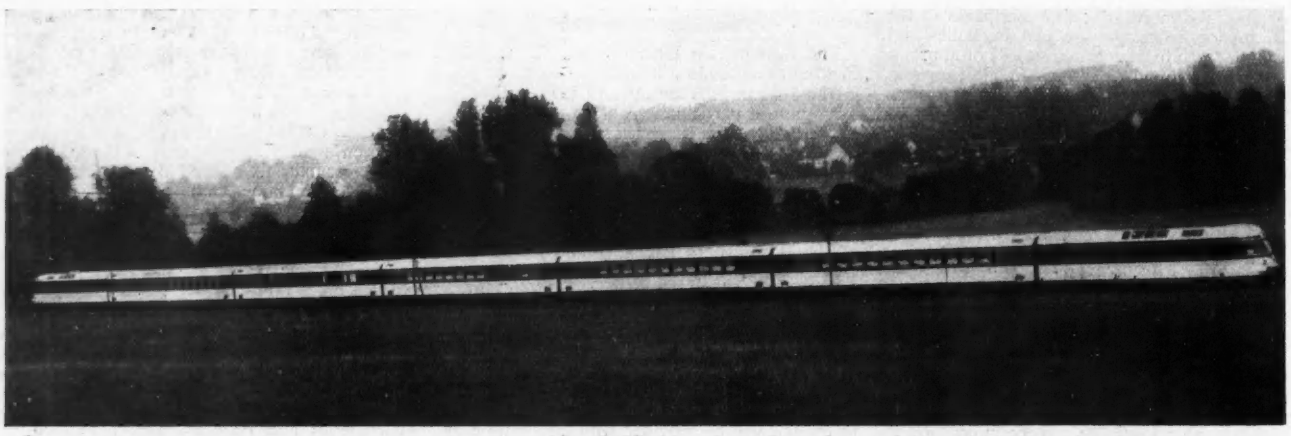
AN axial-flow fan delivering up to 130 cubic metres per hour at 160mm w.g. static pressure, or 70 cubic metres per hour at 400mm w.g., has been developed by A.B. Svenska Fläktfabriken, Stockholm, 7, Sweden. The unit, the model "2PHM," is a two-stage design of which several can be arranged in series to give pressures of up to 1200mm w.g.

The fan is characterised by the fact that the two impellers are counter-rotating. With a single-stage axial-flow fan, part of the velocity imparted to the air is rotational. The velocity energy of this component can be converted into static pressure energy by means of stationary guide vanes. In the present instance, the counter-rotating impellers fulfil this function, in addition to which there is the increase in the axial velocity component appropriate to two stages. Practical tests are stated to have shown that the arrangement gives a pressure rise of about three times that of a single impeller without guide vanes. In theory, the same result could be achieved by a conventional two-stage fan, i.e. two identically driven impellers with guide vanes. It is, however, found that deflection and friction losses in the guide vanes cause the pressure rise to be less than this value.

The fan is mounted in a cylindrical duct provided with a flanged end. The two impellers face each other, with a cylindrical spacer element shrouding the hubs. In order to avoid complications in the drive, each impeller is driven by its own motor which is supported on the walls of the duct by a spider. Since the operating conditions of the two stages are different, the impellers are not identical, although the motors are similar. The shape and number of the blades have been determined not only by the desired pressure rise, but also by considerations of the degree of noise which can be accepted.

The impellers are cast in high-duty light alloy, the first impeller having eleven blades and the second eight. The casing is welded from mild steel sheet. An airtight inspection door enables the sense of rotation to be checked when making the motor connections. As the motors, which are totally enclosed, are placed in the airstream, the ambient air temperature must not normally exceed 40 deg. Cent. Below this point, the motors can be loaded like self-cooled motors because of the forced air cooling.

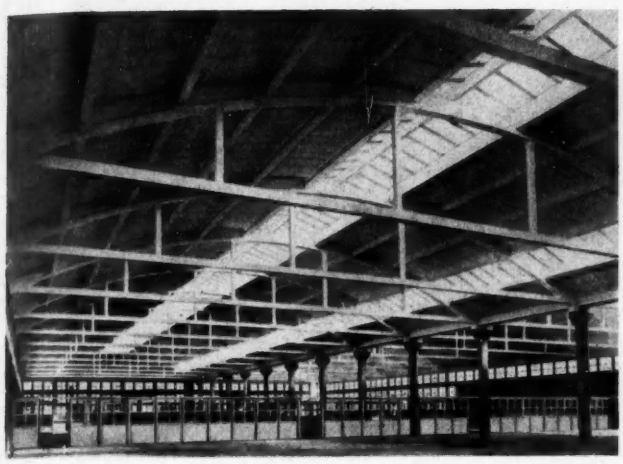
Higher pressures than can be achieved by a single unit are obtained by putting units in series. The factor which limits the number of units which can be combined in this way is cooling. Provided that cooling ability is not impaired, it is stated to be quite permissible to connect up to three units in series.



140km per hour, 275-ton diesel-electric train, comprising two 1100 h.p. motor coaches and five passenger coaches for the Moroccan Railways

Prestressed Concrete in the Netherlands

On January 24, a lecture was given to the Prestressed Concrete Development Group by Ir. A. S. G. Bruggeling at the Institution of Civil Engineers, entitled "Progress of Prestressed Concrete in the Netherlands." At the beginning of his talk, which took place under the auspices of the Cement and Concrete Association, Ir. Bruggeling referred to the first applications, in 1948, which were for simply supported beams for factory roofs. Spans varied from 50ft to 100ft and the beams were cast at the site. Some difficulties were experienced through freezing of the grout, slip of wires in their anchorages, and excessive friction between cable and duct. A footbridge at Waalhaven of 143ft clear span, electrification poles for Dutch railways, and precast arch units for buildings were developments which followed in 1950 and 1951. This early work showed the need for a body to establish close contact between designers and contractors and as a result the Netherlands Prestressed Concrete Development Group (STUVO), which performs similar functions to its British counterpart, was founded on May 10, 1949.



Workshop at Utrecht with prestressed concrete roof structure

Early activities of STUVO related to the production of specifications for prestressed concrete and various aspects of design. This work, the speaker said, had formed essentially the basis for all prestressed concrete developments in the Netherlands.

Some of the problems overcome by STUVO included fractures in the high-tensile wire, fire-resistance gradings, and the frost resistance of grouting mortar particularly where metal cable ducts were used.

Shell roof structures have been the most important development of *in-situ* buildings in Holland and are becoming increasingly common. A special study committee to investigate methods for faster and more accurate calculations of stresses assisted this trend. The largest span shell roofs built in Holland to date are in a chocolate factory at Oosterhont; the factory consists of twenty-two bays, each covered by a shell roof 39ft wide and 130ft long.

There appears to be a preference for precasting and site assembly, which is efficient and economic. One example is the workshops of the AKU organisation at Emmen, with a total floor area of 275,000 square feet. The beams used for the building are freely supported, with prestressed *in-situ* edge beams. Roof slabs are placed over the upper flanges of the beams with ceiling slabs between the bottom flanges.

Another important structure is the Van Gelder and Zonen paper factory at Wormer. The frame of the main hall, 400ft long, 65ft high, and with a width between columns of 65ft, was built from precast mass concrete blocks having a maximum weight not greater than 3 tons. The blocks were joined after assembly by prestressing in situ.

Two examples of the combination of *in-situ* and precast concrete described by Ir. Bruggeling were a floor (at first-floor level) of a hall for the Industries Fair in Utrecht, and a garage at Hertogenbosch. The floor at Utrecht, which consists of two bays, each 156ft square, was designed to hold material awaiting exhibition. In this case, speed of construction was of the utmost importance. A system was chosen in which precast prestressed main beams 156ft long, rested on five *in-situ* columns, 30in square, and placed at 39ft centres; precast prestressed secondary beams at 13ft centres spanned between the main beams to support an *in-situ* reinforced concrete floor slab, 6in thick. In the garage, the 170ft width is made up of two bays of adjacent precast prestressed concrete portal frames at 25ft centres. The two adjacent centre columns are fixed and outer columns are hinged at their base. Five straight cables of twelve 7mm wires were needed to prestress each cross member for the full width of the hall.

In the field of bridge construction, Ir. Bruggeling stated that all the prestressed concrete bridges built in Holland, with the exception of a few small slab bridges, were formed of precast units. The lecturer referred to some details of the more interesting statically indeterminate structures, particularly the connections of the beams, and described the use of continuous cables (the Amstel bridge in Amsterdam, the Drecht bridge at Leimuiden, and the Klaprozen bridge in Amsterdam), and the method of making connections by means of continuity bars in cases where precast beams were used in combination with an *in-situ* deck slab. Examples of the latter practice include a ferryboat pier in Amsterdam and the Ericalaan bridge over the Ypenburg–Burgerveen motorway. Altogether, more than 100 prestressed concrete bridges have been built in the Netherlands.

Among the several special applications of prestressing described was a method of prestressing circular sewage tanks, designed to avoid creating secondary stresses. This method, which had been applied to a plant at Zeist, allows the tank wall to move relatively to the base during stressing and anchoring.

In conclusion, Ir. Bruggeling emphasised the importance placed in the Netherlands on tests, both of complete structures and structural units, an example being the testing to destruction of full-scale models of continuity members. Thorough testing under loading and overload was considered essential to determine safe design figures for more advanced structures.

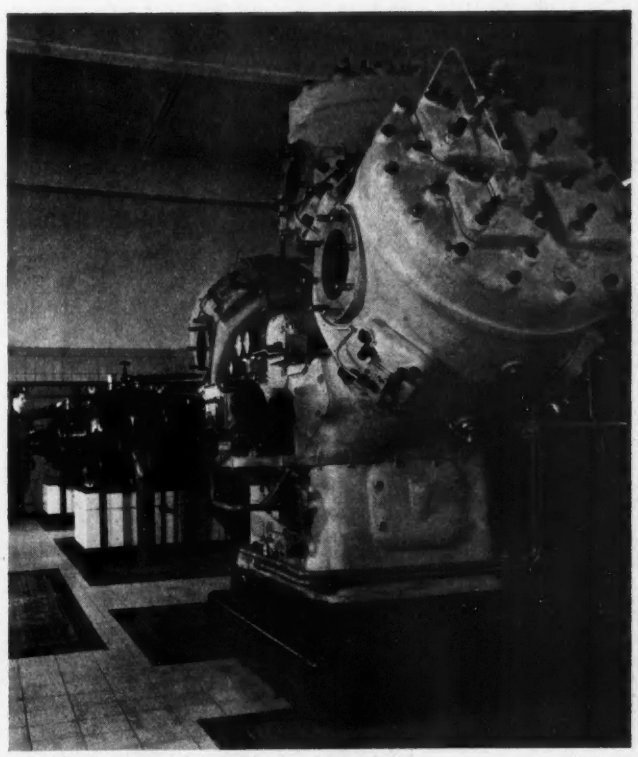
Fan Compressors

A novel design of reciprocating compressor has been evolved by Demag A.G., Duisburg. It is called the fan compressor and is described as a high-speed machine which has a high output in relation to the stroke volume and hence to its size.

The compressors are built either with two or three cylinders. In the first instance, the cylinders are in vee arrangement with an angle of 90 deg. between them. One cylinder works as a high-pressure, the other as a low-pressure cylinder. The second design has its cylinders set at 60 deg. and gives double the output of the two-cylinder arrangement, with pressures in the ratio 9 atmospheres : 12 atmospheres. Output is between 1000 and 10,000 cubic metres per hour. The compressors are used singly or in twin arrangement and can be directly driven by an electric motor.

High efficiency is stated to be obtained by having double-acting cylinders, short gas paths, large cross-sections in the gas passages and plate valves, efficient intercooling, and low piston speeds. The intercooler is placed next to the machine and so saves having a special basement for this purpose. It works on the cross-counterflow principle. In the case of the three-cylinder machine the intercooler is internally subdivided into sections.

Crankcase, crosshead and high-pressure cylinders are made of cast iron, while the low-pressure cylinders consist of light alloy. The crankshaft is an alloy steel forging. The connecting-rods act side by side on the same crankpin, so that the cylinders are not in the same plane, but are displaced axially in relation to one another.



"D2F" compressor, with cylinders arranged fanwise, for 1000 to 10,000 cubic metres per hour

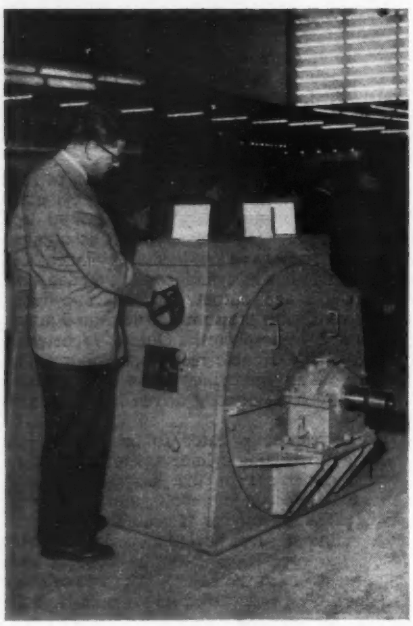
Separate lubrication systems are used, one for the driven components and one for the cylinders. Both lubricating pumps are driven from the crankshaft; oil for the moving parts is cooled by a cooling coil fitted inside the crankcase. A hand pump is provided to lubricate the compressor before it is started up.

Output is adjusted to the demand, without variations in speed, by rapid-acting controls.

Under full load all high- and low-pressure cylinders are in operation. When the load is reduced one side of each cylinder can be put into an idling condition by opening the valves. Additionally, in the case of three-cylinder machines, a whole low-pressure cylinder can be made to idle, so that altogether there are three different running positions with two-cylinder compressors and five different positions with three-cylinder compressors.

Compound-Wound Three-Phase A.C. Motor

In the accompanying illustration may be seen a compound-wound three-phase motor built by Siemens-Schuckertwerke, Berlin and Erlangen, German Federal Republic. With this motor it has been possible to realise a power of 200kW with only six poles, where previously the use of eight or more poles had been necessary for sizes above 100kW. The new design, it is stated, thus constitutes a great saving in weight and cost. Compound three-phase motors allow stepless speed changing, which is carried out without loss



200kW, three-phase, compound-wound a.c. motor. A 1 : 3 speed reduction is possible by moving the brushes by means of the handwheel

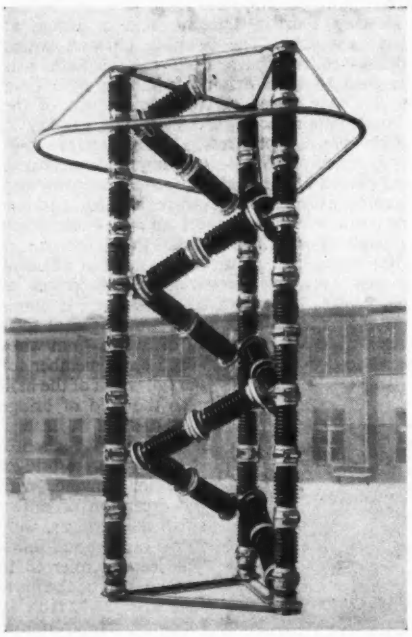
by slewing the carbon brushes round the commutator, either by hand, as in the illustration, or by means of a small electric servo-motor. With the motor shown, the normal motor speed of 1425 r.p.m. may be reduced down to 475 r.p.m., a reduction of 1 : 3. Much greater reductions down to 1 : 50 of maximum speed are stated to be possible.

Among the applications of this class of motor is the drive of printing machines where a very low starting speed must be combined with a high operating speed. Variable speed applications are met with in paper-making, textile manufacture, and in the cement and glass industries, and it is with such applications in view that the new motor has been developed.

380kV Surge Arrester

Surge arresters are employed on outdoor high-voltage equipment in order to protect such equipment from excess voltages caused by switching operations or by lightning. The tendency towards higher transmission voltages has led to a demand for arresters laid out for nominal voltages up to 400kV. In addition, they have to be very robust in order that they should not be damaged even if the surge voltage continues for some time. In order to facilitate the construction of surge arresters suitable for the highest line voltages, Siemens-Schuckertwerke Berlin and Erlangen, German Federal Republic, have designed equipment built up from a number of similar units. Each consists of a hollow ceramic body, which contains the several quenched spark gaps which are arranged in series. The assembly is filled with nitrogen, and has flanges fastened at both ends which prevent bursting of the unit. Should internal overloading occur the arc is immediately transferred to the outside.

The layout of a complete arrester depends upon the voltage at which it is to be used. Up to



Surge arrester for a nominal voltage of 380kV, constructed from a number of similar elements

140kV it is the practice to arrange the units in line, in the form of a vertical column ; from 140kV to 240kV the arrangement is in zigzag, and for still higher voltages the elements are arranged very compactly in the shape of a spiral, as shown in the accompanying illustration.

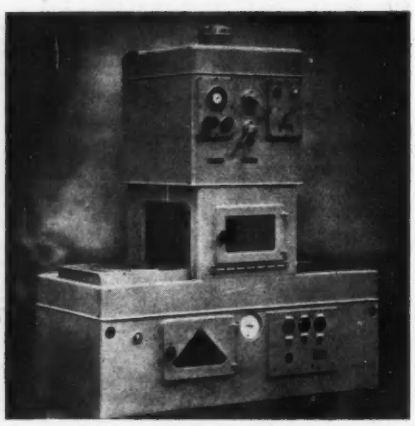
Duplex Quenching Press

The introduction is announced of a duplex table quenching press for use with gears and other components of a maximum length of 11¾in and a diameter of 21⅝in. The machine is manufactured by W. Ferd. Klingelnberg, Söhne, Remscheid, W. Germany.

Although especially intended for spur, helical and bevel gears, the press can accommodate any other kind of component of a size within the capacity given.

The Klingelnberg Model DH550 quenching press is designed to overcome a main cause of distortion by introducing forced flooding of the component with oil, so that during the vital quenching stage uneven dissipation of heat is avoided. The duplex table is a considerable asset for rapid production work, as one of the twin stations may be in the working section of the press while the other is being unloaded.

The work cycle commences with the component lying, unclamped, on the lower die, which stands clear of the machine casing. At the movement of a lever, the table traverses so that the loaded die is moved into the housing ; drop doors controlled by hydraulic valves are closed, and the upper die descends to lie, by its own weight, on the component. Precooling is then effected by flooding from all sides with a flow of cooling oil of even temperature. After a predetermined period, the top die is actuated to clamp the work, and full cooling is achieved by a forced oil flow. A transparent panel at the front of the cooling chamber permits observation of the work during the operation.



Duplex quenching press with automatic cycle

The operating cycle is fully automatic, the times for precooling and total treatment being set on a pair of timer dials housed in a compartment in the base of the machine. A cover, fitted to this compartment, prevents accidental alterations in the settings. At a point ten seconds from the end of the total quenching time, a green lamp is illuminated as a warning to prepare the next component. When the operation is finished, the control lever returns to its initial position, the oil flow stops and drains off and the ram and doors rise.

An electric heater is fitted to bring the oil rapidly to the correct temperature, which may be checked by means of a thermometer. A spherical pressure transmission face between the ram and the top die ensures that the clamping load (maximum value 3 tons) is distributed evenly.

Sykes Machine Tool Company, Ltd., of The Hythe, Staines, Middlesex, is the sole British agent for this machine.

James Watt Medal for Professor Bauersfeld

It is announced that the Institution of Mechanical Engineers has awarded the James Watt International Medal to Professor Dr.-Ing. Walther Bauersfeld, Oberkochen/Württemberg. The Medal was instituted on January 19, 1936, in commemoration of the 200th anniversary of the birth of James Watt. Professor Bauersfeld received the Medal, which is awarded every other year, in recognition of his achievements as scientist, inventor and organiser, especially in connection with the application of precision engineering to optics. Among his more-than-120 inventions are the stereophotographic plotting machine with ancillary lens system, the planetarium, improvements to the Kaplan turbine, and many optical and mechanical designs. He was born in Berlin in 1879, and after studying mechanical engineering at Berlin University, joined the firm of Carl Zeiss in 1905, becoming a member of the board in 1908. After World War II he played a leading part in the rebuilding of Carl Zeiss in West Germany, at Oberkochen. For many years, prior to 1945, Professor Bauersfeld was connected with the University of Jena, where he taught technical physics ; later he became associated with Stuttgart Technical University. His many academic and non-academic honours include the Grosses Verdienstkreuz with star of the Federal Republic, and the Grashof Medal of the Verein Deutscher Ingenieure.

Ninth International Liège Fair

It is announced that the Ninth International Fair at Liège, Belgium, will take place from April 27 to May 12. This Fair is of a purely industrial and technical nature, and its principal sections are devoted to mining equipment, metals, light and heavy mechanical engineering and electrical engineering. Three large exhibition halls cover 7 acres of ground at the site by the River Meuse, and there is an open-air section of 3 acres. Last year there were 476 exhibitors, of which 319 were Belgian, the remainder coming from sixteen different countries ; the total number of visitors was 200,000, of which nearly 13,000 came from abroad. The Fair is represented in the U.K. by R. C. Liebman, 178, Fleet Street, London, E.C.4.

Eriksbergs Mekaniska Verkstads A.B.

At Eriksbergs Mekaniska Verkstads Aktiebolag, Gothenburg, last year, a total of just under 120,000 gross tons was completed or launched, involving an overall main horsepower of 96,006 h.p. and auxiliary power of 13,665 h.p. The ships include four tankers of from 12,800 to 20,400 tons gross and three cargo liners of 5169, 5513 and 8985 tons gross.

Global Distribution of Radioactivity from Nuclear Detonations

BY OUR AMERICAN EDITOR

When Adlai E. Stevenson raised the issue of testing of hydrogen weapons in the recent American presidential election campaign, he touched on one of the most perplexing problems confronting the United States Government. Mr. Stevenson claimed to have received scientific advice that further testing of H-bombs would make a global peril of the radioactive strontium-90 in the fall-out of the weapons. The U.S. Atomic Energy Commission has now published the results of an independent study of the problem which indicate that the genetic dangers for future generations from the present level of testing are comparatively slight.

THE genetic danger in radioactive fall-out from atomic explosions has been a matter of scientific concern and dispute since Alamogordo. For the general public, however, the issue was first dramatically posed when the Japanese fishing boat "Lucky Dragon" was caught in the fall-out of radioactive ash from the first American H-bomb explosion off Bikini on March 1, 1954. That bomb was a "super"—a three-ply bomb involving an atomic explosion triggering a hydrogen explosion which, in turn, fissioned a casing of uranium-238, which is unfissionable except under the great heat and force of an H-explosion. It was the fissioning of the outer uranium casing which produced the great radioactive fall-out. One of the radioactive elements produced was strontium-90, which, when lodged in the body, has an affinity for bone structure, and can cause bone cancer. In view of the public concern over this issue, the U.S. Atomic Energy Commission authorised an independent study of the biological effects of radiation, the results of which have now been released.

The properties that make strontium-90 the most hazardous of the nuclides formed in the fission process are its long half-life (twenty-eight years) and its chemical similarity to calcium. Because of its resemblance to calcium, strontium-90 may be assimilated by biological processes. If ingested by human beings, in food or water, the strontium will deposit, like calcium, in the skeleton. An investigation of the potential hazard from the contamination of soils and the biological food chains by strontium-90 began very early in the United States atomic energy programme. The first studies were associated with the wartime weapons development programme, were theoretical and were intended to identify the principal parameters which influence the long-range effects of nuclear detonations. The initial theoretical studies provided a valuable basis for the experimental approach to the problem which became possible with the weapons testing work which began in 1948 and has continued intermittently to the present time.

The strontium-90 studies have increased in scope and complexity, and the overall programme has for some years been global in extent, involving physical, chemical and biological investigations on land, in the oceans and in the air. Known as "Project Sunshine," and directed at a full understanding of the physical and biological behaviour of the strontium produced in nuclear detonations, these studies are concerned with an unprecedented variety of scientific questions. From the standpoint of its vast geographical dimensions and the variety of scientific mechanisms involved in the investigation, "Project Sunshine" is comparable to the most comprehensive scientific studies ever undertaken. The factors that influence the behaviour of strontium-90 begin in the complex physics and chemistry of the fireball and the mushroom-shaped cloud which forms after a nuclear detonation. The height of the burst above ground, the nature of the terrain and the particle size of the soil and debris sucked into the fireball all influence the fall-out pattern.

When the particles descend to the earth's surface, they leave the domain of the meteorologist and become involved in the physics, chemistry and biology of the soil. How soluble is the strontium-90 in fall-out? Does it leach from the soil? At what rate is it incorporated into plants and how can this rate be expressed quantitatively as a function of the kind of soil and the kind of plant? These are a few of the questions that have been studied in tracing the strontium-90 into the first of the biological links in the food chain between soil and man. The answers to these and many more questions have been obtained by many investigators working in many laboratories throughout the United States. From its formation in a nuclear detonation, until it is metabolised by man, the path of a strontium atom is a long one. Understanding of its route has come from studies which know none of the bounds of the conventional scientific disciplines. The phenomenology of strontium in fall-out can only be described in the combined languages of all the principal combined sciences—geophysics, physical chemistry, biophysics and biological chemistry.

World-Wide Deposition of Fall-Out

The basic procedure for documenting the global fall-out of radioactivity is by means of a network of monitoring stations which have been operated in the United States and abroad since 1951. Until recently this network consisted of eighty-eight stations situated in forty-six countries and territories. During the past few months the network has been augmented by a number of stations sponsored by various additional governments in co-operation with the U.S. Atomic Energy Commission. The monitoring technique is a simple one which consists of exposing a one square foot cellulose ester film covered with an adhesive. The radioactivity in fall-out is largely in particulate form and the dust is collected by impaction against the adhesive surface. The coating is insoluble and retains its adhesive properties when wet, so that in rain the radioactive dust particles are retained by the collection surface. These films are exposed in duplicate for twenty-four hours after which the film is mailed to a central processing facility at the A.E.C. Health and Safety Laboratory in New York. Most of the stations are situated at meteorological observatories where the collection routine can be easily fitted into the schedule of observations and duties.

From 1951 until the latter part of 1955, it was a relatively simple matter to determine the age of the mixed fission products collected daily by the monitoring network. At any given time the fall-out was known to have originated from the most recent test series. Prior to 1954, the fall-out from the detonations would diminish rapidly and would ordinarily be undetectable before the next series of tests started. This was because the yields from detonations were relatively low, and the bulk of the debris was distributed below the tropopause, where fall-out is greatly hastened by precipitation and other factors. The ease with which the age of the radioactive debris could be determined made it a relatively simple matter to estimate the fraction of the total radioactivity that was due to strontium-90, by using the curves of relative isotopic abundance of fission products developed by Hunter and Ballou.

The detonation of devices having yields equivalent to megatons of T.N.T. produces clouds of radioactive debris which pierce the tropopause and become distributed in the stratosphere. From this relatively stable region of the earth's atmosphere the particles descend slowly, and fall-out to the earth's surface occurs over a period of time which is measured in years rather than weeks or months. The traces of relatively old debris from high-yield devices become mixed with the debris of subsequent detonations. This being the case, neither the decay characteristics of a sample nor the relative abundance of the long-lived isotopes can be predicted from theory. Late in 1955 it became apparent that it was increasingly difficult to predict the strontium-90 content of fall-out from theory, because of the mixing of debris from more than one test series. The method of estimating strontium-90 was therefore changed. At the present time increasing reliance is placed on the direct radiochemical analyses of the contents of pots which collect the fall-out continuously for one month. The gummed films will continue to be used as the basic collection device because its simplicity makes it possible to obtain data from a great number of stations. Unfortunately, films cannot be analysed directly for strontium-90, and it has therefore been necessary to devise other means of determining the ratio of strontium-90 to total fission product activity.

The calibration of these gummed films against cylindrical pots indicates that the technique has an efficiency of about 63 per cent for the collection of mixed fission products. It is felt that the sacrifice in collection efficiency is justified by the ease with which the samples can be collected, transported and analysed. The pair of gummed films present a sampling area of 2 square feet per station. Thus, the total area sampled by the network is 176 square feet, which is only 3×10^{-14} of the area of the earth. One must therefore inquire as to the adequacy of the coverage provided by the sampling network and the possibility that areas of the world may exist in which the strontium-90 deposition is very much higher than the values observed at sampling stations situated hundreds of miles apart. The accompanying Table I provides a regional summary of the cumulative fall-out of strontium-90 reported by the collection stations. Stations in the immediate vicinity of the test sites in Nevada and the Marshall Islands are excluded because, as expected, the fall-out patterns in these regions is less regular than elsewhere and the data are therefore not applicable to a discussion of global fall-out phenomena. The table reveals a high degree of uniformity in the cumulative deposition of strontium-90. The mean of the means of the seven geographical areas is 5·8 milli-curies per square mile and the range of values for the seventy-five stations included in the table is 2·9 to 13 milli-curies per square mile. Only two stations in the United States (Boise, Idaho and New Orleans, Louisiana) and none of the overseas stations have values greater than twice the mean of the area means. The uniformity of the depositions suggest it is unlikely that strontium-90 exists in any part of the world, excluding regions near testing sites, in amounts greatly in excess of the upper values reported in the table.

TABLE I—*Regional Summary of Sr-90 Deposition as at September* 1, 1955

Place	No. of stations	Range, milli-curies per square mile	Mean, milli-curies per square mile
Europe and the Middle East	6	4·0— 5·9	5·0
Africa	7	3·0— 6·7	5·4
Japan and South East Asia	11	4·5—11·0	7·0
Australia and New Zealand	4	3·3— 5·6	4·8
Latin America	12	2·9— 8·3	5·4
Canada and Alaska... ...	13	3·0— 6·9	5·1
United States	22	3·4—13·0	7·8

Previous to the present work, W. F. Libby had called attention to a band of relatively high fall-out in the Northern Hemisphere. This band, which Libby attributes to the relatively rapid fall-out of tropospheric debris in the latitudes of the detonations, is not as marked in the world-wide pattern of the gummed film network, although the values for the United States, Japan and South East Asia are noted to be about 50 per cent higher than elsewhere. In general, the values reported here for the Southern Hemisphere are higher than those reported by Libby, but the differences are of little significance in the ultimate estimates of the potential human hazard. In October, 1955, seventeen samples of soils were collected in the United States at places where the adhesive films had been in use since 1951. This study

ndicated that the measured values of strontium in soil were on the average of 1·6 times the estimates based on film collections. It was noted that this relationship did not hold for sampling points situated near the Nevada test site and it was tentatively concluded that the relative enrichment of strontium-90 in the soils at a distance from the test site was due to the fractionation of strontium-90 in the early development of the radioactive cloud or to peculiarities of the desert soils of that region.

More recent analyses of soils at a number of overseas sites have not indicated a clear relationship between the estimates of fall-out derived from soil analyses and from adhesive films. In Fig. 1 are given the results of soil analyses from various parts of the world, as reported by the

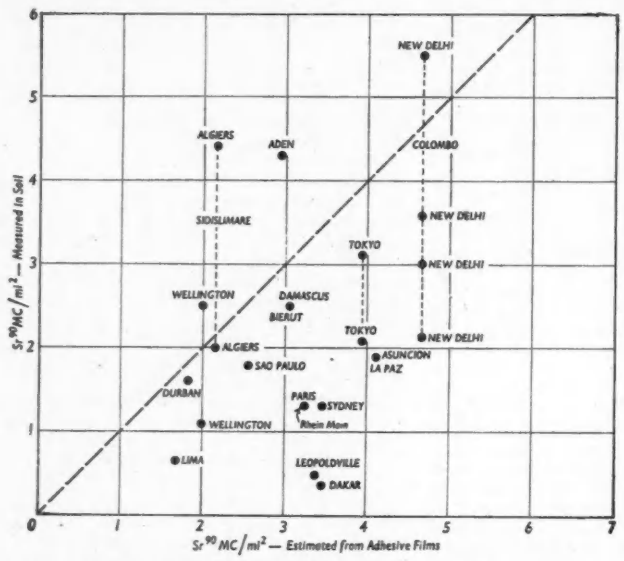


Fig. 1—Adhesive film estimates of Sr^{90} deposit compared with estimates from soil analysis

University of Chicago. The data are plotted against the estimated values of strontium-90 based on predictions from the adhesive film network. In general the estimated values are somewhat higher than the measured values. The reason for this is not understood. The obvious possibility that the strontium-90 is leaching from the soil seems unlikely in view of other data which indicate conclusively that the bulk of strontium-90 in undisturbed soil is retained in the upper 2in and vertical leaching may therefore be said to be negligible. The possibility that the debris is washed horizontally cannot be disregarded, although this possibility seems to be ruled out by other evidence that the debris tends to remain fixed at the site of original deposition. The recovery of strontium-90 from soils is an exceedingly difficult chemical procedure, and it is possible that incomplete recovery of the isotope may, in part, explain the discrepancy noted. Although the number of sampling sites are relatively few in relation to the total surface of the earth, and although no data are available for the large ocean masses, the uniformity of the cumulative deposition of strontium-90 makes it possible to estimate the total strontium-90 deposition over the surface of the earth. The integrated total, based on the adhesive film measurements, at the end of September, 1955 is estimated to have been 1,000,000 curies, with an average deposition of 5 milli-curies per square mile.

Stratospheric Reserve of Strontium-90

A complicating factor in the present studies is that megaton devices inject substantial amounts of fission products into the stratosphere from which deposition proceeds at a relatively slow rate. An evaluation of the potential hazard from the radioactive strontium produced up to any given time requires that one considers not only the strontium-90 already deposited on the earth's surface, but also that which remains in stratospheric storage and will be deposited at some future time. Libby has postulated that the stratospheric reservoir is depleted exponentially, with 50 per cent being removed every seven years. More recent data indicate that this estimate may be slightly high, but the true half-time of deposition is certainly greater than four years. The stratospheric residence time of the bulk of the debris is certainly short in relation to the radiological half-life of strontium-90. If the debris were to be stored in the upper air for a period as long as or longer than the half-life of strontium-90, the potential hazard would be significantly less because the radioactive decay would eliminate appreciable amounts of strontium-90 before deposition to the earth's surface took place. However, since the mean residence time in the stratosphere can be taken to be much less than twenty-eight years, only a small fraction of the strontium-90 will decay before being deposited on the earth's surface. One can therefore estimate the ultimate deposition of strontium by assuming that this nuclide is uniformly mixed in the stratosphere and that the total amount now stored in the stratosphere will be deposited ultimately on the earth's surface. Whether this deposition will be complete in five years or ten is of minor importance in estimating the potential hazard to be expected.

It is possible to sample the stratospheric dust burden and a number of measurements have been reported by British and American investigators. Both groups have collected samples of dust by filtering air, using aircraft at altitudes up to about 45,000ft. In addition, the United States has flown constant level balloons up to 100,000ft and has collected dust samples by electrostatic precipitation as well as by filtering air. The data obtained in these studies indicate that the stratospheric strontium-90 is present in approximately the expected amounts, but there are at the present time insufficient data to permit a reliable estimate of the total stratospheric reservoir of strontium-90. A better estimate of the stratospheric reserve can be obtained at present from material balance studies. The amount of strontium-90 produced on detonations to date can be estimated with some certainty. Estimates of the amounts of strontium-90 that are deposited in the intense fall-out in the vicinity of a detonation are available from extensive investigations conducted during the test programmes in Nevada and in the Pacific. The total strontium produced in a detonation, less the strontium-90 which falls out in the immediate vicinity of the detonation, gives the total inventory of strontium-90 that is available for subsequent deposition at places remote from the site of detonation.

With this approach, it is estimated that the present stratospheric inventory of strontium-90 from detonations to the present time is about three times the total amount that has already been deposited outside of the United States. In the United States, strontium-90 from the Nevada tests was a significant fraction of the strontium-90 fall-out at the end of 1955, so that the proportionate increase will be less in the future from the more uniform deposition of stratospheric debris. The probable average level of world-wide contamination by strontium-90, when all of the strontium-90 produced to date has been deposited, may be approximated as about 20 milli-curies per square mile, by adding 15 milli-curies per square mile to the average deposition of 5 milli-curies per square mile at the end of 1955. This estimate, based on data from the adhesive film network, is in good agreement with Libby's recent estimate of 15 to 17 milli-curies per square mile.

Strontium Levels in Soil

The deposition of strontium-90 in soil must be related to assimilation by biological processes and to absorption by man. The presence of this isotope in soil is significant only because it is potentially available for assimilation by plants, animals and, ultimately, by man. To define the potential risk from a given distribution of strontium-90 on the surface of the earth requires that the distribution be quantitatively related to the skeletal burden of strontium-90 of a human population in dietary equilibrium with the soil from which their nourishment is derived. This equilibrium is already established for a variety of trace elements normally present in the earth's crust. Some of these, like potassium and radium, are radioactive and this is reflected by the presence of these substances in the human body. For example, the upper foot of soil in the United States contains, on the average, about 1000 milli-curies of radium per square mile. The average adult skeleton in this country contains about 10^{-4} micro-curies of radium which is derived from the assimilation of this trace element from foods and water. Thus, the value of 10^{-4} micro-curies of radium represents the amount deposited in the skeletons of the populations whose mineral metabolism is in equilibrium with the soil minerals.

The freshly deposited strontium-90 takes a relatively long time to complete the biological route to bone. At the present time the skeletons of all but very young children were formed prior to the introduction of strontium-90 to the soil. Moreover, bone being formed at the present time utilises calcium which left the soil in months gone by. The fact that cattle may be fed on hay many months old and the hold-up of human foods in the commercial distribution system, are but two of the many factors which would lead one to expect the human strontium-90 burden to lag in time behind the potential value which might ultimately be expected from a given soil concentration. The human skeleton cannot be expected to respond quickly to the gradual accretion of strontium-90 by soil. Equilibrium can be expected to be achieved over a period of years, but not over a period of months.

In the United States, as in a number of other parts of the world where the population derives much of its calcium from dairy products, analyses of milk for strontium-90 provides a method of estimating the levels of human absorption which may be expected in the future. Recent studies

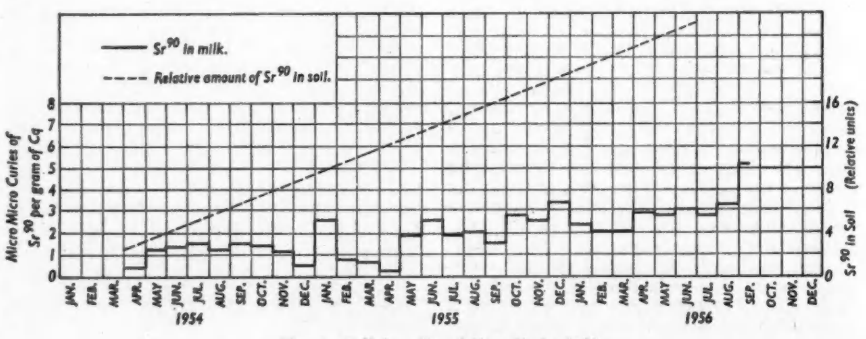

Sr 90 in milk.
Relative amount of Sr 90 in soil.
Micro Micro Curies of Sr 90 per gram of Ca
Sr 90 in Soil (Relative units)
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1954
1955
1956

Fig. 2—Sr^{90} in milk of New York, N.Y.

have shown that when radioactive strontium is incorporated into milk there is no appreciable biological differentiation between calcium and strontium when the milk is fed either to experimental animals or to humans. One may, therefore, assume that when a skeleton is formed by calcium from dairy products, the skeleton will contain the same strontium-90 : calcium ratio that was present in the food. This is apt to be a conservative assumption, other investigations having demonstrated that biological differentiation may take place whereby the specific activity of the calcium in the diet may be as much as two-and-a-half times greater than the specific activity of the calcium deposited in the skeleton. If the assumption that no differentiation takes place is not valid, the error will be on the safe side, since all of the experimental evidence indicates that when differential absorption does occur it is in favour of calcium.

Milk from the metropolitan New York milkshed has been sampled regularly since early 1954. In 1955 the sampling programme was expanded to include other milk sheds in the United States and abroad. The strontium-90 content of the New York milk is presented graphically in Fig. 2, and Table II gives the average value for all sampling points during the first half of 1956. As strontium-90 is not a natural constituent of the earth's crust, it follows that the presence of this isotope in biological materials is due to fall-out from the detonation of nuclear devices during the past few years. Insufficient time has elapsed to reveal whether or not the concentration of strontium-90 in milk bears a linear relationship to the accumulating strontium-90 in soil. The value of between 2 and 3 micro-micro-curies of strontium-90 per gramme of calcium, representing the average range of values reported from mid-1955 to mid-1956, can be explained in two ways, both of which involve contamination of the cattle feed. This contamination may occur by way of the soil, in which case the strontium-90 is incorporated metabolically into the feed, or the contamination may exist as freshly deposited fission products on the surface of the plant. If the contamination in milk results primarily from the latter factor, it would be expected that a cessation of nuclear detonations would be reflected by a diminution of the strontium-90 content in the coming years as the stratospheric inventory of strontium-90 became depleted and the fall-out on to the surfaces of the feed becomes correspondingly less. On the other hand, if the contamination of milk is due primarily to the strontium-90 incorporated metabolically from the soil, the concentration in milk would be expected to increase in proportion to the strontium-90 in soil. The maximum concentration in milk would be reached after the stratospheric reservoir had been deposited in the soils.

TABLE II—*Sr-90 in Milk, January-June*, 1956. (*All values in μμc Sr-90/g Ca*)

	New York	State College, Mississippi	Madison, Wisconsin	Mandan, North Dakota	Portland, Oregon	Japan	England
January	2·3	—	3·0	3·5	—	2·7	4·0
February	2·0	—	3·5	8·1	—	—	4·6
March	2·0	6·3	3·4	11·0	—	3·5	4·0
April	2·9	6·7	3·4	7·7	5·2	3·0	—
May	2·8	4·9	2·8	10·0	6·4	—	2·9
June	3·0	4·4	3·4	8·7	5·0	—	—
Average	2·5	5·6	3·3	8·2	5·5	3·1	3·9

It will be noted from Fig. 2 that a steep rise occurred in the metropolitan New York milk supply in early September, 1956. It is not now known whether this rise is due to the relatively heavy fresh fall-out from foreign detonations conducted last summer or to an increase in the amount of strontium-90 incorporated metabolically from the increasing amounts of strontium-90 in the soil. If the former hypothesis is valid, the milk concentration can be expected to diminish in succeeding weeks. If the increase is sustained, it is presumably a reflection of the increasing amount of strontium-90 in soil. As a basis for comparison with the soil values, the curve of cumulative strontium-90 in the New York area is superimposed on the milk curve. It will be noted that since 1954 the cumulative fall-out of strontium-90 is increasing steadily with time, but even if one accepts the recent increase in the strontium content of milk, the latter is at a much slower rate. The deposition of strontium-90 in the soils of the metropolitan New York milk shed in the early autumn of 1955 is estimated to have been 6·5 milli-curies per square mile. The expected maximum in this area is thus 21·5 milli-curies per square mile when the stratospheric inventory of strontium-90 is deposited. This is an increase by a factor of 3·3. In the summer of 1955 the milk in this area averaged 2·5 micro-micro-curies per gramme of calcium. If one assumes that the milk concentrations will increase in proportion to the soil content of strontium-90, the maximum value that can be attained in metropolitan New York milk of the future, from detonations to date, is about 8·3 micro-micro-curies of strontium-90 per gramme of calcium. It should be noted again that this is a conservative assumption which ignores the possibility that much of the strontium-90 in milk may be ingested by the cows as fresh fall-out on the surface of plants. If one further assumes that no differentiation between strontium and calcium will occur in the process of converting milk to human bone, 8 micro-micro-curies of strontium-90 per gramme of skeletal calcium becomes the upper limit of the foreseeable strontium burden in the population of this area from detonations which have already occurred. A factor of three should be ample to define the upper limit of hazard elsewhere in the United States where, as in North Dakota, the strontium-90 uptake is proportionately higher than in metropolitan New York. On this basis, 25 micro-micro-curies of strontium-90 per gramme of calcium is the highest foreseeable skeletal burden in the United States. This estimate is likely to be reduced as new information about the uptake of strontium-90 eliminates some of the uncertainties which have prompted the use of highly conservative assumptions. Although this estimate is higher than Libby's recently estimated upper value of 10 micro-micro-curies per gramme of calcium, the agreement is excellent considering the fact that the two estimates are based on different approaches and that both are deliberately conservative.

The data from the world-wide fall-out collection network indicate that the fall-out is distributed throughout the portion of the world that has been sampled in a remarkably uniform manner. If the potential strontium hazard in an agricultural area anywhere is greater than in those areas in the United States for which the milk data in Table II serve as indices, the reason is likely to be found in the soil chemistry of the region or the dietary habits of the people. There is good evidence that the uptake of strontium-90 is influenced markedly by the amount of calcium available to growing plants. For any given amount of strontium-90 in soil, the uptake into plants will vary inversely with the available calcium present in the soil. Plants growing on soils which are depleted in calcium assimilate more strontium-90 than otherwise. The manner in which differences in the dietary habits of populations influence the strontium-90 uptake requires further study. Leafy vegetables can be expected to have a higher ratio of strontium-90 to calcium because of direct deposition on the surface of the leaves. For example, in a crop of snapbeans grown in Maryland in the summer of 1956, the leaves assayed 78 micro-micro-curies of strontium-90 per gramme of calcium, whereas the beans assayed only 2·2 micro-micro-curies of strontium-90 per gramme of calcium. As it is doubtful that any differentiation between strontium and calcium occurs metabolically within the plant, the difference is presumed to be due to the distribution of fresh fall-out on the leaves.

Two methods are available for quickly screening populations to determine if any unusual factor or combination of factors is contributing to a higher strontium-90 uptake. Although the sampling of human bones is of limited value in assessing the strontium-90 burden which may be expected when an equilibrium is reached, the method is satisfactory for comparing populations at any given time. Kulp and Eckelmann have recently completed several hundred analyses of human bones in the various countries of the world and find little difference between one area and another, except that United States values, on the average, are higher than those which they found elsewhere in the world. They report an average of 0·35 micro-micro-curies of strontium-90 per gramme of calcium in the bones of children in the Eastern United States at a time when the milk assayed almost ten times as high. Another screening method which appears promising is the analysis of pooled urine samples. Only a few data are available but it is known that strontium-90 is detectable in the urine of individuals in the Eastern United States. The level in early summer of 1956 was about 1 to 2 disintegrations per minute per litre. In a population in which the dietary intake of strontium-90 is relatively uniform, the strontium-90 excretion can perhaps be used as a measure of the strontium-90 intake. Additional data should be obtained for other parts of the United States and for other countries.

The Hazard of Strontium-90 in Bone

The above reasoning suggests that a maximum of 25 micro-micro-curies of strontium-90 per gramme of calcium is foreseeable in human bones perhaps a decade hence when biological equilibrium is reached with the strontium-90 produced up to the present time. This figure is arrived at by making the deliberately conservative assumption that the presently observed values of strontium-90 in milk represent the equilibrium values between milk and soil, and that henceforth the milk concentration of strontium-90 will bear a linear relationship to the deposition of strontium-90 in soil. It is further assumed that the human body does not differentiate between strontium and calcium and that the specific activity of skeletal calcium will therefore be equal to the specific activity of milk calcium. The maximum foreseeable value of 25 micro-micro-curies of strontium-90 per gramme of calcium when integrated over the life span, is equivalent to 7·6 to 33 per cent of the dose from natural sources of skeletal radiation.

The variability of the skeletal dose due to natural radioactivity is largely due to differences in the body radium content, which has been shown to vary from one geographical region to another. The gamma-ray dose received externally from terrestrial sources is likewise quite variable, depending on the kinds of rocks in the vicinity.

The U.S. National Committee on Radiation Protection recommends 1 micro-curie of strontium-90 as the maximum permissible continuous burden for occupational exposure. It is generally accepted that for public exposure an additional safety factor of 10 is advisable and on this basis one-tenth of a micro-curie of strontium-90 would be the maximum permissible body burden for public exposure. This is equivalent to 100 micro-micro-curies of strontium-90 per gramme of skeletal calcium. The recommended maximum value of 100 micro-micro-curies per gramme of calcium, being intended for continuous exposure, is not directly applicable to an evaluation of the potential risk from detonations to date. The natural radioactive decay of strontium-90 will reduce to 0·5 the dose delivered in the lifetime of individuals who, from birth, begin to accumulate skeletal calcium initially containing 25 micro-micro-curies per gramme.

Summing up, the world-wide distribution of the strontium-90 produced in weapons tests up to the present time can be expected to rise to approximately 20 milli-curies per square mile in the latter part of the next decade. Because of the chemical resemblance of strontium to calcium, strontium-90 tends to be assimilated by plants, ultimately finding its way into foods and man. The highest estimate of the skeletal dose that can be foreseen from devices detonated to date is 7 per cent of the upper values of the dose delivered by natural radioactivity and may prove to be as little as 0·7 per cent.

Personal and Business

Appointments

MR. JOHN EDEN has joined W. P. Butterfield, Ltd., Shipley, Yorks, as contracts manager.

MR. C. T. ALDERSON has been appointed a director of Ruston and Hornsby, Ltd., Lincoln.

MR. S. A. MOUSLEY has been appointed general manager of the belting division of the Dunlop Rubber Company, Ltd.

MR. W. J. VAUGHAN has been appointed technical sales representative for north-east England of Newall Group Sales, Ltd.

MR. ALEC GARDNER MEDWIN has been appointed head of the industrial division of the Council of Industrial Design.

MR. T. L. CIASTULA, A.M.I.Mech.E., A.F.R.Ae.S., has been appointed chief designer (helicopter division) of Saunders-Roe, Ltd.

DE HAVILLAND HOLDINGS, Ltd., states that Mr. Hugh Buckingham and Mr. P. C. Garratt have been appointed special directors.

JOHNSON AND PHILLIPS, Ltd., has announced the appointment of Mr. J. C. Robertson, A.M.I.E.E., as manager of its London branch.

MR. RALPH R. WARREN has been appointed personnel manager of Westland Aircraft, Ltd., and of its subsidiary company, Normalair, Ltd.

MR. F. W. COOPER, M.I.Mech.E., M.I.Prod.E., has been appointed education and technical officer to the Institution of Production Engineers.

THE NATIONAL COAL BOARD has announced the appointment of Dr. William Reid as chairman of the Durham division in succession to Mr. E. H. D. Skinner.

MR. T. H. EXELBY has been appointed generation engineer of the Sudan Light and Power Company, Ltd., and will be in charge of the Burri Power Station, Khartoum.

LIEUT.-COLONEL G. W. KIRKLAND, M.I.Struct.E., M.Inst.H.E., M.Cons.E., has been elected chairman of the committee of the Prestressed Concrete Development Group for 1957.

DR. WILFRED MERCHANT, M.I.Struct.E., has been appointed to the newly-created chair in structural engineering in the faculty of technology of the University of Manchester.

MCKECHNIE BROTHERS, Ltd., metals division, states that Mr. L. Hewitt has been appointed London area manager (sales) and Mr. H. Hollingworth, Midland area manager (sales).

ARMOUR AND CO., Ltd., has announced the appointment of Mr. F. K. Johnson to its chemical division to handle the sale of cationic chemicals to the petroleum industry in the United Kingdom.

CHLORIDE BATTERIES, Ltd., states that Mr. D. S. Howarth, Grad.I.E.E., has been appointed manager, stationary battery sales. Mr. S. H. Chase, M.I.E.E., has retired after thirty-three years' service with the company.

THE FURNESS SHIPBUILDING COMPANY, Ltd., states that Mr. Robert Boardman has retired from the office of managing director and that Mr. W. T. Butterwick and Mr. J. H. Cross have been appointed joint managing directors.

BOWMAKER (PLANT), Ltd., has announced the following appointments: Mr. J. E. Brown, commercial manager, has been appointed a director; Mr. Barry Smith has been appointed sales manager, and Mr. W. L. Johnson, assistant sales manager.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., informs us that Mr. A. Paterson continues as assistant works manager of the Trafford Park works. Mr. R. R. Whyte, as stated in our issue of January 25, has been appointed assistant works manager (mechanical), for the large and small turbine departments and the company's Germiston Works, Glasgow.

PIRELLI-GENERAL CABLE WORKS, Ltd., has announced the following appointments: Mr. I. McWhirter has been appointed London manager in succession to Mr. E. H. S. Bullen, who will retire on March 31. Mr. Bullen will be retained in a consultative capacity. Mr. B. Campbell Smith has been appointed district sales engineer for north-west England. Mr. G. Eastland has been appointed assistant to Mr. R. Bunch, Midlands area, and will operate from Birmingham.

RICHARDSONS, WESTGARTH AND CO., Ltd., states that the board of directors of the Humber Graving Dock and Engineering Company, Ltd., has been reconstituted, following the acquisition of the share capital by Richardsons, Westgarth. Mr. T. R. Hawkes and Mr. F. H. Sedgwick have resigned. Mr. O. J. Philipson has been appointed chairman; Mr. J. O. M. Fisher, managing director, and Mr. J. R. Mackay and Mr. A. A. E. Wise, directors. Mr. C. K. Bird and Mr. E. Butler-Henderson continue as directors.

THE HEPWORTH AND GRANDAGE GROUP OF COMPANIES has announced the following appointments, resulting from the death of the late chairman and managing director, Mr. Elijah Hepworth: Mr. J. L. Hepworth and Mr. G. C. Hepworth have been appointed joint managing directors, and Mr. J. H. Mallinson, sales director of Hepworth and Grandage, Ltd. Mr. G. C. Hepworth has been appointed managing director, Mr. J. L. Hepworth, director, and Mr. A. T. Beacham, director and secretary of Hepworth and Grandage (Yeadon), Ltd. Mr. H. Forrest has been appointed managing director, and Mr. A. T. Beacham, director and secretary of Leeds Piston Ring and Engineering Company, Ltd.

Business Announcements

LIPTAK FURNACE ARCHES, Ltd., states that it has changed its name to Liptak, Ltd.

MR. J. M. STOREY, managing director of Dewrance and Co., Ltd., is visiting the U.S.A.

STEAM PLANT ACCESSORIES, Ltd., states that it has changed its name to A. P. Green (Great Britain), Ltd.

MR. K. F. DORMER, technical director of Mackay Industrial Equipment, Ltd., is touring the United States and Canada.

MR. R. NORTHOVER, chief engineer of T. Wall and Sons, Ltd., has retired after more than thirty-six years' service with the company.

MR. A. D. BARNSDALE, Midland area technical representative of the Coventry Gauge and Tool Company, Ltd., has relinquished his appointment.

BRITISH CENTRAL ELECTRICAL COMPANY, Ltd., 6 and 8, Rosebery Avenue, London, E.C.1, states that its telephone number has been changed to Terminus 3666.

AIR CONTROL INSTALLATIONS, Ltd., states that it has opened a branch office at Cross House, Westgate Road, Newcastle upon Tyne, 1 (telephone, Newcastle 28861).

ROCKWELL MACHINE TOOL COMPANY, Ltd., states that it has been appointed sole agent in the United Kingdom for the range of machines manufactured by Peltzer and Ehlers, Krefeld, Germany.

MR. DUNCAN CAMPBELL, chairman of Charles Carr, Ltd., and the Non-Ferrous Casting Company (Birmingham), Ltd., is leaving this country on February 14, and will visit the West Indies and Central and South America.

HAWKER AIRCRAFT, Ltd., announces that the production of "Hunter" fighters is to be withdrawn from Squires Gate, Blackpool, to Kingston-on-Thames. The government-owned plant at Blackpool has been run by Hawker Aircraft since 1949 and is now the biggest single aircraft production unit in Europe, employing nearly 4000 people: the factory will run down very shortly.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., announces that it has concluded an agreement with Paul Ferd. Peddinghaus, of Gevelsberg, Germany, under which it has the right to use Peddinghaus designs of handling fixtures for use on induction heating applications where applicable. Paul Ferd. Peddinghaus is appointed sole agent for the sale and service of Wild-Barfield a.h.f. induction heating equipment in Germany.

BRISTOL AIRCRAFT, Ltd., announces the formation of a new "Weston Division" of Bristol Aircraft, Ltd., incorporating the factories at Oldmixon and Banwell. Bristol helicopter activities are now concentrated at Oldmixon. At the Banwell factory, the company is engaged in large-scale manufacture and development of rocket motor tubes for British guided missiles and research vehicles, in addition to a wide range of high pressure gas storage vessels for use in aircraft and guided weapons.

HEAD WRIGHTSON AND CO., Ltd., has announced the virtual completion of the reorganisation of the group into subsidiary companies by the formation of the following wholly owned subsidiary companies: Head Wrightson Teesdale, Ltd. (at present the engineering division), Head Wrightson Iron and Steel Works Engineering, Ltd. (at present the McKee division), Head Wrightson Stockton Forge, Ltd. (at present the Stockton forge division), Head Wrightson Iron Foundries, Ltd. (at present the iron foundries division). These companies will take over and expand the field of operations of the divisions mentioned.

Contracts

THE MINISTER OF TRANSPORT AND CIVIL AVIATION, Mr. Harold Watkinson, on the advice of Messrs. Frederick S. Snow and Partners, the Ministry's consulting engineers for Gatwick Airport, has awarded the contract for the construction of the terminal building to the Turiff Construction Corporation, Ltd., of Warwick. The value of the contract is £939,286. The architects for the terminal building are Messrs. Yorke, Rosenberg and Mardall.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY Ltd., has received a contract valued at about £750,000, from the British Transport Commission for the supply, jointing and supervision of installation of ninety route-miles of 33kV, 3-core oil-filled cable and pilot/supervisory cable for the British Railways' Kent Coast electrification scheme. This scheme covers the electrification of the Southern Region from Gillingham to Ramsgate, and the Canterbury, Dover and Folkestone Lines. The whole installation is required for commissioning not later than December 1, 1958, and it is anticipated that cable-laying will start in April, 1957.

HUMPHREYS AND GLASGOW, Ltd., Humglas House, Carlisle Place, London, S.W.1, has received an order for the installation of two carburetted water gas sets at the Kobe works of the Osaka Gas Company, Japan. Both sets have been designed for heavy oil enrichment and the total output of the installation will be 10,500,000 cubic feet of carburetted water gas daily. The value of the order is approximately £250,000. The major part of the plant will be built in Japan, and special equipment will be supplied from this country by Humphreys and Glasgow, Ltd. The installation is expected to be completed and put into operation early next year.

Miscellanea

NUCLEAR WEAPON TESTS.—The Decca Navigator Company, Ltd., announces that a Decca "Navigator Mobile Chain" will be used during the nuclear tests which will be held in the Central Pacific later this year.

SEDIMENTOLOGY LABORATORY.—We are advised that the Shell Petroleum Company, Ltd., has given £20,000 to assist in the establishment of a laboratory in sedimentology in the Department of Geology in the University of Reading.

CATHODIC PROTECTION.—We learn from Metal and Pipeline Endurance, Ltd., that it is to fit impressed current cathodic protection to the ballast compartments of an ore carrier building at Swan, Hunter and Wigham Richardson, Ltd.

ANTIOXIDANT PLANT.—It is stated by Imperial Chemical Industries, Ltd., that the "Topanol O" plant, now under construction, will be in operation by mid-1958, and will produce 1600 tons per annum for this lubricating oil and gasoline antioxidant.

OPEN UNIVERSITY SCHOLARSHIP.—The Lockheed Hydraulic Brake Company, Ltd., announces that the Lockheed Open University Scholarship, tenable for honours study in mechanical sciences from October, 1958, at Emmanuel College, Cambridge, has been awarded to Mr. M. R. Grundy.

16,000 LB TURBO-JET.—A Bristol "Olympus" 6 engine has now completed an observed 150-hour type test at 16,000 lb thrust. The 16,000 lb engine is now stripped for inspection prior to issue of a type test certificate. Development to higher powers is in hand: thrusts of over 17,300 lb were recorded during the type test.

SULPHUR RECOVERY PLANT.—We are informed by The Mond Nickel Company, Ltd., that the International Nickel Company of Canada, Ltd., has concluded an agreement with the Texas Gulf Sulphur Company for the operation of a pilot plant, for the recovery of sulphur from sulphur dioxide, at Copper Cliff, Ontario. The plant will be built near to the company's new iron ore recovery plant and will consist of two sections, one for gas scrubbing and cleaning and one for reduction of the sulphur dioxide to elemental sulphur.

WRECK RETURNS.—Lloyd's Register of Shipping has issued its returns of merchant ships totally lost for the quarter ended June 30, 1956. The world total of steamships and motorships lost consequent upon casualty amounted to 27 ships of 30,255 tons gross, which included 4 ships of 2253 tons belonging to Great Britain and Northern Ireland, and 5 ships of 977 tons owned by the other Commonwealth countries. The corresponding totals of ships broken up, &c., were 92 ships of 129,252 tons gross, 43 ships of 46,091 tons and 6 ships of 12,302 tons.

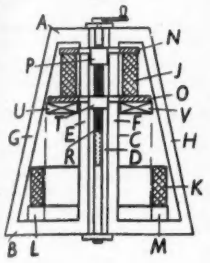
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

ELECTRICAL ENGINEERING

764,699. March 29, 1954.—REGULATING TRANSFORMERS, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1-3, St. Paul's Churchyard, London, E.C.4. (*Inventor: John Charles Spencer.*)

The invention relates to regulating transformers having primary and secondary windings which are movable relatively to each other so as to allow for current regulation by reactance variation. They are suitable to be used where a wide range of secondary current is required, such as for arc welding. The invention aims at substantially increasing the range of reactance adjustment and current regulation without greatly increasing the dimensions of the transformer. This is achieved by combining the movable winding with a magnetic shunt member. As shown in the drawing, the core of the transformer is of the shell type having upper and lower horizontal yoke members *A* and *B*. A vertical centre limb *C* is provided with a bore *D* and longitudinal slots *E* and *F* for accommodating a winding displacing mechanism. Outer limbs *G* and *H* of the core are slanting so as to form between them and the centre limb windows which taper towards the upper yoke. Windings *J* and *K* are arranged about the centre limb *C*. One of them, preferably the secondary winding *K* in the case of a welding transformer, for instance, is stationary and is supported on the lower yoke *B* through the intermediary of spacers *L* and *M*. The other winding *J*, the primary in this case, is clamped between upper and lower end structures *N* and *O*. The structure *N* extends through slots *E* and *F* and is secured to a nut *P* which engages a lead screw *R* in the bore *D*. When the screw is rotated the winding *J* travels up and down. The lower structure *O*, which also extends through slots *E* and *F*, is secured to a guiding sleeve *T* which is movable in bore *D*. The transformer construction so far described is largely known and disclosed in Specification No. 612,100. According to the invention, a magnetic shunt member comprising left-hand and right-hand portions *U* and *V* is arranged to be movable with the winding *J*. The member may comprise packets of laminations of magnetic material fastened to the structure *N*. The shunt member provides an effective leakage path when the winding *J* is in the narrow portion of the window, but has no effect when the shunt member and winding *J* are in the wider portion of the transformer window. Thus the regulating range of the transformer is considerably increased. The invention can be readily applied to core constructions as shown in the Specification No. 612,100.—*January* 2, 1957.

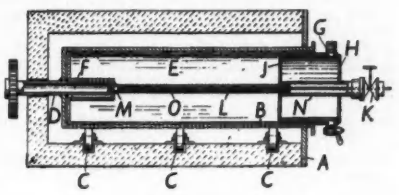


No. 764,699

METALLURGY

764,779. February 14, 1955.—ROTARY FURNACES, Diffusion Alloys, Ltd., 18, Maddox Street, London, W.1. (*Inventor: Jean Borgnon.*)

In the metallurgical industry use is frequently made of rotary furnaces, more particularly for the mass heat-treatment of small and medium-sized objects. The invention has as an object to develop the advantages of furnaces of this kind and to effect substantially continuously controlled atmosphere treatments comprising cooling at a controlled speed. Referring to the drawing, it will be seen that the furnace comprises a refractory brick chamber closed at its forward end by a front *A* through which extends the head of a rotary retort *B* which is of cylindrical form and which is adapted to rotate within the chamber about a substantially horizontal axis. For this purpose the retort rests upon three pairs of rollers *C*. The retort is extended rearwardly by a shaft through the wall of the furnace. Keyed to the shaft *D* is a gear wheel by which the retort is rotated. The retort can be heated by any desired means. Inside the rotary retort *B* is a removable retort *E*, the external diameter of which when hot is very slightly smaller than that of the rotary retort *B*. The space between the walls of the two retorts is small to ensure efficient heat transfer. The shaft *D* penetrates some distance into the retort, and is closed at its inner end to form a housing or chamber *F* to receive temperature-measuring means, which show in conjunction with error tables the exact temperature inside the removable retort. The end of the removable retort *E* has an outer radial flange *G* against which bears a closure cover *H* with a suitable fluid-tight packing clamped between the flange and cover. It will be seen in the drawing that the cover *H* is at some distance from the front *A* so as to be as far as possible from the heat of the furnace and to obviate deformations of the cover. The furnace is operated as follows. The objects to be treated are charged into the annular space surrounding the tube of the removable retort *E*, charging being terminated when the level is reached corresponding to the position of the false bottom *J* of the cover. The cock *K* is opened so as to place the interior of the retort in communication with the



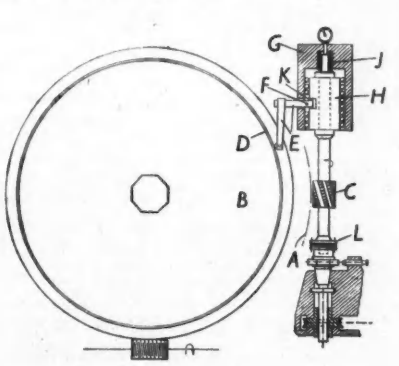
No. 764,779

ambient air. If the treatment to be carried out does not need a special internal atmosphere or if this atmosphere is created in the heart of the mass being treated, the cock is kept open until the retort reaches the treatment temperature and is then closed for the duration of the treatment to prevent any entry of air. If the treatment needs a special atmosphere—for example, a reducing, halogenated or other atmosphere, the internal tube *L* is connected to an appropriate gas source. A relatively rapid flow of gas issuing from the tube passes through orifices *M* in the base of the retort and expels the air from the retort through the annular gap between the tubes *N* and *O*. Once scavenging has been effected, the speed of gas flow can be reduced to the value required for the process being used. When the treatment is terminated, the retort *E* is cut off from the atmosphere and withdrawn from the retort *B*, and, according to the required cooling cycle, is placed in a heated chamber, in a medium which is a poor heat conductor or in the open air. Depending upon requirements, the retort can be kept closed for the duration of cooling or a flow of appropriate gas maintaining the desired atmosphere in the heart of the retort can be caused to circulate.—*January* 2, 1957.

MACHINE TOOLS

765,940. November 26, 1953.—GEAR HOBBING MACHINES, Craven Brothers (Manchester), Ltd., Vauxhall Works, Reddish, Stockport; and Willie Owen, of the company's address.

The invention relates to gear hobbing machines and has for its object to provide improved means for correcting pitch errors which may occur in the hobbing of master wheels to be used in such machines. Referring to the drawing, the gear wheel *A* which is being cut is carried on the table *B* and is operated upon by the hob *C*. Motions are given to the table and to the hob in the ordinary way. After the wheel has been cut by the hob it is measured and the variation of pitch of the wheel duly noted. Mounted upon the table is a corrector rail *D*, similar in general character to that shown in Specification No. 765,939. This rail is carried on adjustable brackets around the periphery of the table and operates a lever *E* pivoted at *F* in the



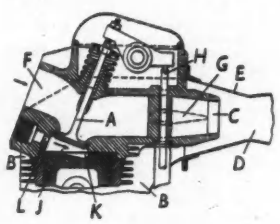
No. 765,940

block *G*, which is part of the hob slide of the machine. The corrector rail is adjusted in accordance with measurements of the gear *A*. The hob slide carries, in a ball slide, the tail block *H*, which controls the position of the hob. The block *H* is under the influence of a spring *J*, which presses the block against the lever *E* at the point *K*, so exerting pressure on the corrector rail *D*. The block is permitted to float with relation to its drive by means of a flexible plate *L* in the drive. It will be seen therefore that as the table *B* rotates, carrying with it the wheel *A*, if the corrector rail *D* has been adjusted in accordance with the measurements made of the wheel, then end motion will be given to the block *H* in order to move the hob bodily in one direction or the other in accordance with the long or short portions of the wheel *A* and thus correct the wheel.—*January* 16, 1957.

INTERNAL COMBUSTION ENGINES

766,302. February 14, 1955.—FOUR-STROKE DIESEL ENGINES, Slobodan Dobrosavljevic, 5, Perside Milenkovic, Beograd, Yugoslavia.

The invention relates to monovalve four-stroke diesel engines with air cooling, having a cylinder in which both the charging as well as the discharge of the cylinder is performed by the same valve. In accordance with the invention, the engine supercharger or blower delivers air to a common distribution duct in the cylinder head, which serves both for charging and discharging the cylinder through the same valve *A* without the assistance of any auxiliary inlet or discharge valves. The air serves both for the charging of the cylinder and internal cooling of the elements of the cylinder head, as well as for the supplementary external cooling of the cylinder assembly by air drawn through jackets *B* around it



No. 766,302

by means of the combined ejector action of the surplus charging air and exhaust gases flowing through the outlet nozzle *C* of the duct, by utilisation of ejector venturi *D*. The cooling air flow is blown into the ejector duct *E* over the externally finned surfaces of the cylinder and cylinder head. This combined inlet and discharge duct contains a straight-line intake *F* for the air delivered from the supercharger. This intake is inclined with respect to the cylinder axis to provide underneath it space for the fuel injector. The discharge part of the distribution duct embodies a vane *G* of substantially aerofoil section as indicated by its chain-dotted line with a hole to provide a free and thermally protected passage for the push rod *H* of the valve mechanism. In this design the vortex combustion chamber is displaced eccentrically in the plane of symmetry of the cylinder head up to the periphery of the cylinder itself, towards the fuel injector. The combustion chamber is composed of a cavity *J* at the bottom of the cylinder head in the form of a transversely tapering section of a circular cylinder coaxial with the valve axis, inclined towards the engine cylinder axis in the discharge direction, and a corresponding cavity *K* in the crown of the piston in the form of a transversely tapering segment. Fuel is injected into this chamber in a conical jet through the aperture *L*. Thus, by the flow effect of the air in the cylinder at the end of the compression from the narrowed space between the cylinder head and the piston, into the eccentrically located combustion chamber, an atomisation of the fuel spray will be produced accompanied by the generation of a double vortex.—*January* 16, 1957.

765,631. March 11, 1955.—TWELVE-CYLINDER TWO-STROKE V-ENGINE, Klockner-Humboldt-Deutz Aktiengesellschaft, Deutz-Mülheimerstrasse 149/155, Köln-Deutz, Germany.

According to the invention, there is provided a slot-controlled twelve-cylinder, two-stroke V engine, characterised by the ignition sequence 1, 6, 3, 5, 2, 4, or 1, 6, 4, 2, 5, 3, for one bank of cylinders, so that no two adjacent cylinders of the bank fire successively. The risk of interference between the scavenging of adjacent cylinders does not then arise. On account of this it is possible for each bank of cylinders to have a single continuous exhaust pipe. Excessive loading of the bearings is likewise avoided. The invention may be used to particular advantage in two-stroke engines which are driven with loop scavenging, especially of the reverse loop type, referred to as Schnürle scavenging.—*January* 9, 1957.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 8.—BRISTOL AND W. OF ENGLAND BRANCH : Grand Hotel, Bristol, "High Frequency Heating Application," A. Hogan, 8 p.m.

Mon., Feb. 11.—CENTRAL LONDON BRANCH : White Hall Hotel, Bloomsbury Square, London, W.C.1, "Light Sources," G. V. McNeill, 7.30 p.m.——N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, "Carbon Brushes : Their Application in Electrical Machines," P. E. Lyddon, 8.15 p.m.

Tues., Feb. 12.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, "Theory of Atomic Energy and Industrial Application," J. H. Fremlin, 8 p.m.——YORK BRANCH : Royal Station Hotel, York, "Level Control Equipment," R. H. Stanard, 7.30 p.m.

Wed., Feb. 13.—BIRMINGHAM BRANCH : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Temperature Measurement," D. Smith, 7.15 p.m.——BRADFORD BRANCH : Midland Hotel, Bradford, "The Cobalt Unit at the Regional Radiotherapy Centre," A. E. Holland, 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 13.—W. MIDLANDS SECTION : Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton, "An Automatic System for Electronic Component Assembly," K. M. McKee, 6 p.m.

Thurs., Feb. 14.—MERSEYSIDE SECTION : Chambers of Commerce, 1, Old Hall Street, Liverpool, 3, "Radioactivity and its Measurement," E. W. Pulsford, 7 p.m.——SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Earth Satellite Project," P. H. Tanner, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., Feb. 12.—Chemistry Building, King's College, Victoria Road, Newcastle upon Tyne, "An Introduction to Prestressed Concrete," R. C. Blyth, 7 p.m.——College of Further Education, William Street, Slough, "Concrete Placing and Formwork," A. B. Harman, 7.30 p.m.

Wed., Feb. 13.—Technical College, 159, Tadcaster Road, York, "An Introduction to Prestressed Concrete," R. C. Blyth, 7.15 p.m.——University College of S. Wales and Monmouthshire, Cardiff, "Influence Coefficient Methods of Statically Indeterminate Structural Analysis," P. B. Morice, 9.30 a.m., and "Design and Analysis of Prestressed Concrete Statically Indeterminate Structures," P. B. Morice, 2.30 p.m.

Thurs., Feb. 14.—University College of S. Wales and Monmouthshire, Cardiff, "Energy Approximations in Structural Analysis," P. B. Morice, 9.30 a.m., and "An Outline of the Highway Bridge Design Problem," P. B. Morice, 2.30 p.m.——Medway College of Technology, Horsted, Maidstone Road, Chatham, "Recent Developments in Prestressed Concrete," S. C. C. Bate, 7.15 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Fri., Feb. 15.—Organic Lecture Theatre, University of Hull, "Radioactive Techniques in Industry and Research," G. B. Cook, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Feb. 11.—LONDON MEETING : Royal Institution, Albemarle Street, London, W.1, Trotter-Paterson Memorial Lecture, "Some Experiments on the Interference of Waves," Sir Lawrence Bragg, 6 p.m.——LEEDS CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "Glassware for Artificial Lighting," D. Keenan, 7 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Feb. 11.—DUNDEE BRANCH : Mathers Hotel, Dundee, "Experiences in Shipbuilding," J. Liddle, 7.30 p.m.

Tues., Feb. 12.—MANCHESTER BRANCH : Textile Institute, Blackfriars, Manchester, Joint Meeting with Institute of Fuel, "Coal Mining," F. G. Glossop, 7.15 p.m.

Wed., Feb. 13.—E. MIDLANDS BRANCH : County Hotel, Theatre Square, Nottingham, "Boiler-House Management," O. H. Barker, 7 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "The More Effective Use of Semi-Skilled Labour," E. Strong, 7.15 p.m.

Thurs., Feb. 14.—MERSEYSIDE AND N. WALES BRANCH : Exchange Hotel, Liverpool, "Warehouse Handling, with particular reference to Unit Loads," J. G. Boyne, 7.15 p.m.——N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "The Plant Engineer and Work Study," D. F. A. Sinclair, 7 p.m.

INSTITUTE OF FUEL

Wed., Feb. 13.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "The Rise of a Hot Waste Gas Plume," C. H. Bosanquet, 5.30 p.m., and "Maximum Gas Concentration at Ground Level from Industrial Chimneys" A. C. Best, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 11.—JUNIOR SECTION : 85, Minories, London, E.C.3, Discussion on "The Management of a Ship," 6.30 p.m.——W. OF ENGLAND SECTION : Grand Hotel, Bristol, "Marine Lubrication," G. H. Clark, 7.30 p.m.

Tues., Feb. 12.—85, Minories, London, E.C.3, "Boiler Feed Water Treatment for Advanced Steaming Conditions," J. Leicester, 5.30 p.m., and "Corrosion in Scotch Marine Boilers," F. Wormwell, G. Butler, J. G. Beynon and H. C. K. Ison 5.30 p.m.

Wed., Feb. 13.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, and "The Development of the Gas Turbine," A. W. Pope, 7.30 p.m.——MERSEYSIDE AND N.W. SECTION : Technical College, Birkenhead, "Modern Marine Steam Turbines," J. H. Gooch, 7.15 p.m.

Thurs., Feb. 14.—N.E. COAST SECTION : Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, Annual General Meeting, and "Recent Developments in Marine Diesel Engines," W. Kilchenmann and P. Jackson, 6.15 p.m.——KINGSTON UPON HULL AND E. MIDLANDS SECTION : College of Technology, Park Street, Hull, "Launching of Ships," R. S. Hogg, 7.30 p.m.

Fri., Feb. 15.—MERSEYSIDE AND N.W. SECTION : The College of Technology, Liverpool, "Launching of Ships," R. S. Hogg, 7 p.m.

INSTITUTE OF METALS

Tues., Feb. 12.—S. WALES LOCAL SECTION : Department of Metallurgy, University College, Singleton Park, Swansea, "Neutron Irradiation Effects in Metals," J. G. Ball, 6.45 p.m.

Thurs., Feb. 14.—BIRMINGHAM LOCAL SECTION : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Modern Developments in Forging, Rolling and Extrusion," A. R. E. Singer, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Feb. 15.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation and Traffic Control Over the North Atlantic," D. D. O. Fraser, 5.15 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Feb. 11.—NORTHERN CENTRE : N.E. Electricity Board, Carliol House, Newcastle, "Plastic Tubing : Manufacture and Application for Water Supplies and Irrigation," W. L. Thorne, 6.45 p.m.

Tues., Feb. 12.—INFORMAL MEETING : 6, Buckingham Gate, London, S.W.1, "Jungle Clearance and Reclamation," C. S. L. Frances, 5 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 12.—WORKS CONSTRUCTION : Great George Street, Westminster, London, S.W.1, "The Employment of Contractor's Plant on Civil Engineering Construction Works," R. H. McGibbon and J. H. Brans, 5.30 p.m.

Thurs., Feb. 14.—GRADUATES' AND STUDENTS' SECTION : Royal Victoria Hotel, Sheffield, "Civil and Structural Engineering Aspects of Factory Design," H. C. Husband, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Feb. 9.—LONDON GRADUATE AND STUDENT SECTION : Visit to Houses of Parliament, Heating, Ventilating and Sound Equipment, 10.30 a.m.

Mon., Feb. 11.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, "The Visit of the British Electricity Supply Delegation to the Soviet Union," J. Eccles, 6.30 p.m.——MALVERN AND DISTRICT GROUP : M.E.B. Sports Club, Hilton Road, Worcester, "Thermal Rating of Transformers," H. W. Hardern, 7.30 p.m.——N.E. CENTRE : Neville Hall, Newcastle upon Tyne, "Engineering Efficiency, Economics and Expediency," P. J. Ryle, 6.15 p.m.——S. MIDLAND SUPPLY AND UTILIZATION GROUP : Imperial Hotel, Birmingham, "Temperature Rises in Electrical Machines as Related to the Properties of Thermal Networks," J. J. Bates and A. Tustin ; "Temperature Rises in Electrical Machines on Variable Load and with Variable Speed," A. Tustin and J. J. Bates ; "Performance and Heating Curves for Motors on Short-Run Duties," A. Tustin, D. F. Nettell and R. Solt, 6 p.m.——SOUTHERN CENTRE : Guild Hall, Southampton, Faraday Lecture, "Nuclear Energy in the Service of Man," T. E. Allibone, 6.30 p.m.——WESTERN CENTRE : Electricity House, Colston Avenue, Bristol, "A New Meter for the kVA Demand Charge," P. Baxter, 6 p.m.

Tues., Feb. 12.—LONDON GRADUATE AND STUDENT DISTRICT MEETING : Public Library, Chelmsford, "The Search for Petroleum : Its Production in the Field, Transportation and Refining," C. B. F. Auld, 7 p.m.——MEASUREMENT AND RADIO SECTIONS : Savoy Place, London, W.C.2, Joint Meeting, "The Ultimate Performance of the Single-Trace, High-Speed Oscillograph," and "The Design and Performance of a New Experimental Single Transient Oscillograph with Very High Writing Speed," M. E. Haine and M. W. Jervis, 5.30 p.m.——E. MIDLAND CENTRE : Loughborough College, Loughborough, "Some Applications of Mercury Arc Rectifiers," A. Wren, and "The Transductor as Applied to Distance Protection," H. Barber, 6.30 p.m.——N. IRELAND CENTRE : Engineering Department, Queen's University, Belfast, Informal Evening, "Electronics and Automation," H. A. Thomas, 6.30 p.m.——RUGBY SUB-CENTRE : Rugby College of Technology and Arts, Rugby, "Brushless Variable-Speed Induction Motors," F. C. Williams, E. R. Laithwaite and L. S. Piggott, 6.30 p.m.

Wed., Feb. 13.—FARADAY LECTURE : Central Hall, Westminster, London, S.W.1, "Nuclear Energy in the Service of Man," T. E. Allibone, 6 p.m.——N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "Some Aspects Concerning Fundamental Principles and Applications of Power System Protection," A. M. Wesley, 7.30 p.m.——N.W. RADIO AND TELECOMMUNICATION GROUP : Engineers' Club, Albert Square, Manchester, "Frequency-Modulated Quartz Oscillators for Broadcasting Equipment," W. S. Mortley, 6.45 p.m.——N. LANCASHIRE SUB-CENTRE : N.W. Electricity Board, North Road, Lancaster, "Germanium and Silicon Power Rectifiers," T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell, 7.15 p.m.——OXFORD DISTRICT MEETING : S. Electricity Board, 37, George Street, Oxford, "Fuel and the Future," John Wilks, 7 p.m.

Thurs., Feb. 14.—UTILIZATION SECTION : Savoy Place, London, W.C.2, "Self-Compensated Alternators," P. J. Bhatt ; "The Metal Rectifier and Its Importance to the Electrical Engineer," D. Mangnall ; "The Automatic Factory," G. F. Stewart, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Electrical Engineering Department, Queen's College, Dundee, "Some Aspects concerning Fundamental Principles and Applications of Power System Protection," A. M. Wesley, 7 p.m.——S.W. SUB-CENTRE : Standard Telephones and Cables, Ltd., Dowlish Ferd Mills, Ilminster, "The Generation and Synthesis of Music by Electrical Means," A. Douglas, 4 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Feb. 11.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Some Problems in the Design for Production of Mining Equipment," L. R. Mann, 7.15 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Feb. 13.—St. Bride Institute, Bride Lane, Fleet Street, London, E.C.4, "Materials Handling and Stores Control," A. J. Cross, 6 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 12.—39, Elmbank Crescent, Glasgow, "Electronics and Engineering," D. S. Gordon, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Feb. 12.—BIRMINGHAM AND DISTRICT BRANCH : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Manufacture and Applications of Forced Air Heaters," G. L. Johnson, 6.30 p.m.——S.W. BRANCH : County Hotel, Taunton, "Heating and Hot Water in Flats," K. W. Dale, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 8.—1, Birdcage Walk, Westminster, London, S.W.1, General Meeting, in Conjunction with the Industrial Administration and Engineering Production Group, "The Economics of Plant Replacement and Renewals," C. W. Griffiths, 6 p.m.——SCOTTISH BRANCH : Robert Gordon's College, Aberdeen, "The Salvaging of Ships, with particular reference to the 'Empress of Canada,'" W. R. Colbeck, 7.30 p.m.

Sat., Feb. 9.—N.E. GRADUATE SECTION : Visit to Quasi-Arc, Ltd., Team Valley Trading Estate, Gateshead, 10 a.m.

Mon., Feb. 11.—LUTON A.D. CENTRE : Luton Town Hall, Luton, "Rubber Springs for Vehicle Suspension," A. E. Moulton and P. W. Turner, 7.30 p.m.——SCOTTISH GRADUATE SECTION : Room 24, Royal College of Science and Technology, Glasgow, "Manufacture of Transformers," S. A. B. Gray, 7.30 p.m.

Tues., Feb. 12.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, General Meeting, "Sealing Rings for Wet Cylinder Liners," J. L. Hepworth ; "Recent Developments and Modern Techniques in the Use of Gaskets," M. G. Herrington ; "Design and Application of Thermostats to the Internal Combustion Engine Cooling System," S. H. Blazey ; "Gudgeon Pin Location," R. C. Cross, 6 p.m.——N.W. GRADUATE SECTION : Engineers' Club, Albert Square, Manchester, "Nuclear Power," R. V. Moore, 6.45 p.m.

Wed., Feb. 13.—N.W. BRANCH : Liverpool Engineering Society's Rooms, 9, The Temple, 24, Dale Street, Liverpool, Joint Meeting with Liverpool Engineering Society, "The Salvaging of Ships, with particular reference to the 'Empress of Canada,'" W. R. Colbeck, 6 p.m.——S. BRANCH : Sun Hotel, Chatham, Kent, "Overdrives," S. H. Ashby, 7.30 p.m.——LONDON GRADUATE SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "Gear Design and Production," M. A. Sargent, 6.30 p.m.

Thurs., Feb. 14.—YORKSHIRE BRANCH : Chemistry Lecture Theatre, University, Leeds, "Fatigue under Triaxial Stress : Development of a Testing Machine and Preliminary Results," J. L. M Morrison, 6.30 p.m.——N.W., A.D., CENTRE : Engineers Club, Albert Square, Manchester, "Brake Usage under Service Conditions," N. Carpenter, 7.15 p.m.

Fri., Feb. 15.—Church House, Westminster, London, S.W.1, General Meeting in Conjunction with the British Nuclear Energy Conference, Thomas Hawksley Lecture, "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," Sir Claude Gibb, 6 p.m.

Sat., Feb. 16.—N.E. GRADUATE SECTION : Visit to the Lackenby Works of Dorman-Long, and Co., Ltd., Middlesbrough, 10 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 8.—EASTERN REGION : Diocesan Hall, Tower Street, Ipswich, "Production Methods in Large Scale Engineering Jobbing Work," J. F. Rice, 7.30 p.m.

Mon., Feb. 11.—E. AND W. RIDINGS REGION : Grand Hotel, Sheffield, "Continuous Casting," I. M. D. Halliday, 6.30 p.m.

Tues., Feb. 12.—S. REGION : Town Hall, Oxford, "Material Control," W. E. Stanley, 7.30 p.m.——E. AND W. RIDINGS REGION : Danum Hotel, Doncaster, "Invention Can Become a Habit," G. Jackson, 7 p.m.——MIDLANDS REGION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Properties and Some Uses of Titanium," R. L. Preece 7 p.m.

Wed., Feb. 13.—N.W. REGION : Radiant House, Bold Street, Liverpool, "Modern Production and Its Influence on Costs," J. P. Wilson, 7.30 p.m.——SCOTTISH REGION : North British Hotel, Princes Street, Edinburgh, "The Work at Leith Docks," M. C. White, 7.30 p.m.——LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, "The Design and Production of Die Castings in Zinc Base and Aluminium Alloys," P. A. R. Findlay, 7.15 p.m.

Thurs., Feb. 14.—N. MIDLANDS REGION : Bell Hotel, Leicester, Annual General Meeting, and "The Solution of Managerial Problems by Operational Research," S. J. Gielnik, 7 p.m.——SOUTHERN REGION : Polygon Hotel, Southampton, "The Planning Engineer in the Management Team," L. E. Bunnett 7.15 p.m.

Fri., Feb. 15.—WALES REGION : Central Library, Alexandra Road, Swansea, "Co-operation and Understanding between Management and Shop Floor," D. H. Davies, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 11.—PRESTON SECTION : Bull and Royal Hotel, Church Street, Preston, "Polyester Isocyanite Foams," J. T. Watts, 7.15 p.m.——S. WALES AND MONMOUTHSHIRE SECTION : King's Head Hotel, Newport, "Moulds and Moulding," F. Sicelton, 7.30 p.m.

Tues., Feb. 12.—LONDON SECTION : Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Comparison of Different Types of Heating in the Rubber Industry," J. R. Happer, 5.30 p.m., and "Dipped Goods Processing and Production," S. D. Sutton, 7 p.m.——W. OF ENGLAND SECTION : Melksham House, Melksham, "Work Study in Germany," G. P. Wade, 7.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Feb. 12.—LONDON GRADUATES' AND STUDENTS' SECTION : 11, Upper Belgrave Street, London, S.W.1, "Structural Engineering and Atomic Energy," D. R. R. Dick, 6.30 p.m.

Wed., Feb. 13.—LANCASHIRE AND CHESHIRE BRANCH : College of Building, Liverpool, "Welded Steel Structures," A. V. R. Hooker, 6.30 p.m.

Thurs., Feb. 14.—11, Upper Belgrave Street, London, S.W.1, "Post-War Developments in German Steel Bridges and Structures," G. B. Godfrey, 6 p.m.——LANCASHIRE AND CHESHIRE BRANCH : College of Technology, Manchester, "Welded Steel Structures," A. V. R. Hooker, 6.30 p.m.——YORKSHIRE BRANCH : Royal Victoria Hotel, Sheffield, "Structural and Civil Engineering Aspects of Factory Design," H. C. Husband, 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 8.—ORDINARY MEETING : Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Kinematic Design," R. J. Herbert, 7 p.m.

Mon., Feb. 11.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, "Power Station Construction," S. S. Ellam, 7.30 p.m.——N.W. SECTION : Engineers' Club, Albert Square, Manchester, "Argon Arc Welding," R. Blackburn, 7.30 p.m.

Fri., Feb. 15.—INFORMAL MEETING : Pepys House, 14, Rochester Row, Wetsminster, London, S.W.1, "The Application of Pneumatic Controllers to Automatic Process Control," G. A. Wapling, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Feb. 13.—24, Dale Street, Liverpool, Thomas Lowe Gray Lecture, "The Salvaging of Ships," W. R. Colbeck, Joint Meeting with Institution of Mechanical Engineers, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Feb. 14.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "Work Hardening and Dislocation Theory," A. H. Cottrell, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 8.—Engineers' Club, Albert Square, Manchester, 2, "The Post-War Trend of Power Station Plant Design," F. J. Hutchinson, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Feb. 13.—Science Museum, South Kensington, London, S.W.7, "The Staunches and Navigation of the Little Ouse River," Ronald H. Clark, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 8.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "The Development of Refractory Nozzle Blades for Use in High Temperature Gas Turbines," T. H. Blakeley and R. F. Darling, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 12.—4, Hamilton Place, London, W.1, "Vibration Problems Associated with the Helicopter," O. L. L. Fitzwilliams, 7 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 13.—John Adam Street, Adelphi, London, W.C.2, "The Development and Use of Glass Fibres," A. Hudson Davies, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Wed., Feb. 13.—STUDY SECTION : E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "The Statistical Aspects of Census Taking," B. Benjamin, 6.15 p.m.——N.E. GROUP : Armstrong Building, King's College, Newcastle upon Tyne, "Testing Taste and Smell," W. A. Pridmore, 7 p.m.

Thurs., Feb. 14.—GLASGOW GROUP : Institute of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Measuring the Development of Reliability in Machines," G. Morris, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Feb. 12.—14, Belgrave Square, London, S.W.1, "Some Aspects of British Standards in relation to Chemical Engineering in the Chemical Industry," D. E. B. Greensmith, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Feb. 14.—CONTROL SECTION : Manson House, Portland Place, London, W.1, Annual General Meeting, "A Servo Speed Control for a Camera Crane," K. G. Crack, 6 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Feb. 14.—Institute Buildings, Park Place, Cardiff, "The Design, Construction and Performance of Approved Type Battery Mining Locomotives and Factors Governing their Selection, Depending on the Duties Required," Colin C. Forbes, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Feb. 15.—39, Elmbank Crescent, Glasgow, "The Heat, Fuel and Power Balances in an Integrated Steel Works," J. A. C. Cowan and J. Roberts, 6.45 p.m.